NAVELEX 0101,102

NAVAL SHORE ELECTRONICS CRITERIA

NAVAL COMMUNICATIONS STATION DESIGN

DEPARTMENT OF THE NAVY
NAVAL ELECTRONIC SYSTEMS COMMAND
WASHINGTON , D.C. 20360

JUNE 1970

LIST OF EFFECTIVE PAGES

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FOREWORD

PURPOSE

This handbook presents ready-reference criteria for the planning, installation and checkout of system and equipment installations at shore communications stations. Users of this handbook, such as planning, engineering and supervisory installation personnel, will find criteria concerning system configuration details, interface between the various elements of the communications station, and integration of equipment into the overall shore station complex. Topics pertinent to a communications station are treated as comprehensively as possible, by including either established standards or current practices that have been proven in the field. References to source documents are included for various topics in the text, and all sources used in the preparation of the handbook are listed in appendix A.

The material in this handbook is intended to present acceptable practices for system design and installation and to establish a basis for standardization of shore communications station systems; however, no handbook can substitute for detailed planning and sound engineering judgment in the design of each project.

SCOPE

The discussion in this handbook is confined to the buildings and the installed equipments at the three sites that comprise a communications station: the communications center, the transmitter station, and the receiver station. Technical information and planning factors pertinent both to new construction projects and to the installation of individual equipments in existing facilities are included. Discussions of transmitting and receiving systems are oriented toward HF radio communications since MF, LF, and VLF radio communication systems will be topics of other handbooks of this series. Equipments and systems external to the buildings, such as antennas and transmission lines, are covered in NAVELEX 0101,104 — "HF Radio Antenna Systems," and discussions concerning the propagation path and general site selection criteria are contained in NAVELEX 0101,103 — "HF Radio Propagation and Facility Site Selection."

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CHAPTER 1

STATION ELECTRONIC SYSTEMS PLANNING

1.1 BASIC PLANNING PROCEDURE

The communications resources for a naval shore station are planned and implemented on the basis of overall Navy requirements. These requirements include those of the Defense Communications Agency (DCA) and those of other services that the Navy may support.

Individual shore station resource requirements are set forth in a document entitled "Communications Operating Requirements" (COR) promulgated by Commander Naval Communications Command. The development of resource capabilities to satisfy the COR is the responsibility of the Naval Electronic Systems Command (NAVELEX). To meet this responsibility NAVELEX has developed a formal planning procedure that requires preparation of a Base Electronic System Engineering Plan (BESEP). A BESEP translates the functional requirements of the COR into a statement of resource requirements, and it details the engineering plan for meeting the objectives of the project.

Requirements for changes to an existing facility may be made known by the operating command of the station. Such may be the case when operational requirements exceed the station capability or when general updating of equipment is required as the result of normal wear or technical advances. In any case, the method of meeting these requirements is through preparation of a BESEP by NAVELEX. Specific details of the content required in a BESEP are contained in the effective edition of NAVELEX Instruction 11000.1.

1.2 COMMUNICATIONS OPERATIONAL REQUIREMENTS

The COR documents are oriented toward individual stations and are maintained as current catalogs of circuits being supported (active circuits) and those planned for the near future. Changes to the circuit requirements for a station are initiated by revising or re-issuing the COR.

The COR for a station identifies distant terminals and local tributaries and specifies the radio-frequency band for each link to a distant station. In addition, the circuit operational function, type of emission, and other identifying data are shown. The information included in figures 1-1 and 1-2 does not represent the requirements for any particular location but is merely intended to show the general content of a COR. For overall circuit planning, a system designer would use the COR for each terminal station to ensure that sufficient equipment is available or is being planned, and to verify that circuit characteristics are compatible.

Radio Communications Operating Requirements for U. S. Naval Communications Station (Location)

NDW-NC-2302/1 (REV 10-67)

LINE ITEM (A)	IANAP DESIG (B)	CIRCUIT FUNCTION (C)	FREQUENCIES (D)	EMISSION (E)	QTY (F)	SVC (G)	STATUS (H)	RANGE (I)	EST. POWER (J)	XMT (K)	REC (L)	CRYPTO/TERM	REMARKS (N)
1	A 11.3	PRIMARY SHIP/SHORE	4-30 MHz	0.1A1	2	SX	ACTIVE	2000	5 kW	3	3		
2	A 03	MULTICHANNEL BROADCAST	2-30 MHz	3A7J	1	BC	ACTIVE	2000	100 kW 40 kW 10 kW	1LF 1HF 2HF		1 KW-37 R 1 KW-37 T	REMOTE KEYING
3	A 21.4	HARBOR COMMON	2716 kHz	6A3	1	SX	ACTIVE	300	100 W	1	1		REMOTE TO OPERATIONS CENTER
4	B 31.01	UNIVERSAL AIR/ GROUND	3-25 MHz	3A3J	2	SX	ON REQUEST	1000	10 kW	2	4		
5	C 17.11	MICROWAVE INTERSITE LINK	1700-2400 MHz	5600P9	1	DX	ACTIVE	LOS	10 W	2	2		TRANSMITTER TO/FROM COMM CENTER
6	D 10.1	NAVSTA(LOC) TO/FROM LONDON	3-24 MHz	9A9B	1	DX	PLANNED	3000	40 kW	2	2		16 CHANNELS VFCT, FY 72
7	D 12.10	NAVSTA (LOC) TO/FROM SPAIN	3-30 MHz	6A9B	5	DX	ACTIVE	1000	100 kW	3	3		DCS CIRCUIT

NOTE: This is a sample only and the entries have no relationship to operational doctrine or directives.

Figure 1-1. Representative COR Page

Teletypewriter/Voice/Data Communications Operating Requirements For U. S. Naval Communications Station (Location)

NDW-NC-2303/1 (5-66)

ITEM (A)	TERMINAL TO (B)	CIRCUIT DESCRIPTION (C)	STATUS (D)	CIRCUIT (E) TYPE	SPEED	MODE	COMCEN CRYPTO (F)	QTY (G)	COMCEN CLASS (H)	FUNCTION/REMARKS (I)
1	NAVCOMMSTA WASH	ORDERWIRE	ACTIVE	DX	75BD	TTY	KW 26	1	S	
2	US COAST GUARD	DCS COMMON USER	ACTIVE	DX	75BD	TTY	KW 7	2	S	
3	NSC NORFOLK	DCS COMMON USER	PLANNED	DX	300BD	TTY	KG 13	1	TS	AUTODIN TERMINAL
4	OPCONCEN	ORDERWIRE	ACTIVE	SX	75BD	TTY	KW 7	1	S	
5	NAVCOMMSTA WASH	DCS COMMON USER	ACTIVE	DX	75BD	TTY	KW 26	4	S	
7	BASE OPS	LOCAL LOOP	ACTIVE	DX	75BD	TTY			U	4 CIRCUITS

NOTE: This is a sample only and the entries have no relationship to operational doctrine or directives.

Figure 1-2. Representative COR Page

CHAPTER 2

SYSTEM STANDARDIZATION

2.1 GENERAL

The Naval Electronic Systems Command prepares and issues system plans for the processing and distribution facilities to be engineered for each type of shore station system. Use of these plans ensures uniformity of facilities and aids in standardizing operating procedures. The Defense Communications Agency (DCA) prescribes the Defense Communications System (DCS) HF radio circuits to standardize processing and distribution facilities for point-to-point communications within the DCS.

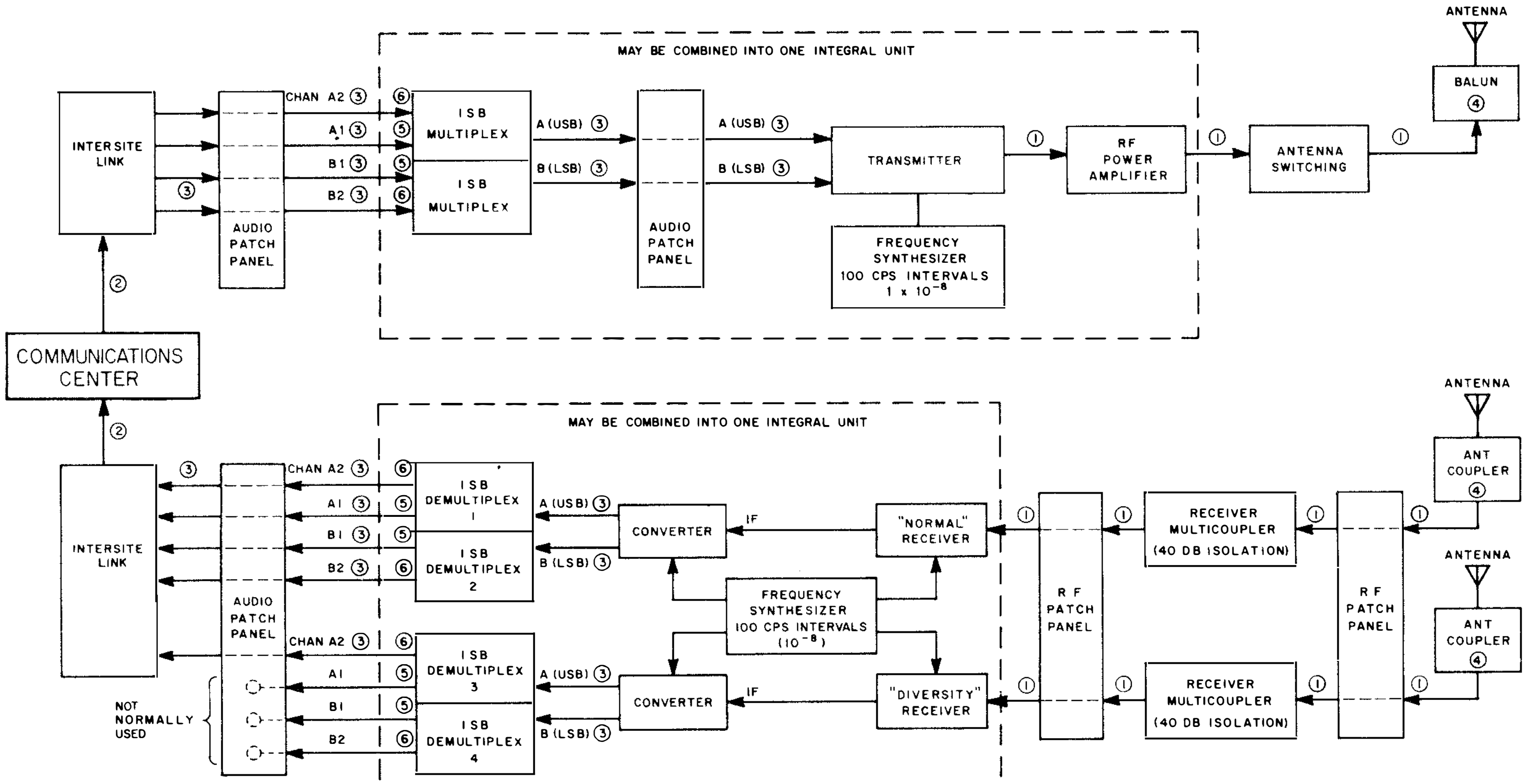
Naval Communication Stations provide tactical communications, interface with DCS facilities, and act as DCS relay terminals. A station meets these communications requirements by implementing circuits in accordance with the needs at a particular time. To maintain flexibility of communications capabilities, the installed systems and equipment are designed, where possible, to satisfy both the DCS and Navy requirements.

2.2 DCS HF RADIO CIRCUIT

The DCS HF radio circuits provide for long-haul, point-to-point composite transmissions that carry a large portion of today's high-volume traffic load. The basic publications that prescribe the DCS radio circuit requirements are: DCAC 330-175-1 — "DCS Engineering Installation Standards Manual" and DCAC 370-185-1 — "DCS Applications Engineering Manual." The basic circuit is shown by figure 2-1. This circuit is composed of one to four channels, each with a bandwidth of 3 kHz. The independent sideband (ISB) technique is used to transmit up to four of these channels within the authorized 12-kHz bandwidth. When ISB techniques are used, the sideband channel allocations are as shown in figure 2-2.

2.3 STANDARD PLANS

Standard plans are the detailed installation design drawings required to accomplish a shore communications equipment installation. The Naval Electronics Systems Command is responsible for the preparation of the plans and publishes a quarterly standard plans cross reference index. These plans include technical data, notes, bills of material (material lists), outline and mounting dimensions, wiring details and terminating information for internal and external cabling (wire run lists), power cable charts and other data pertinent to naval electronic equipment system installations. The plans are standard F-size (28" x 40") drawings on reproducible mylar vellums. The standard plans are divided into three general types as follows:



NOTES:

① 50 OHM COAXIAL LINE
② MICROWAVE OR LAND LINE
③ 600 OHM BALANCED LINE
④ 600 OHM BALANCED TO 50 OHM UNBALANCED
⑤ RESPONSE BETWEEN TRANSMITTER INPUT AND RECEIVER OUTPUT ± 0.5 DB, FROM 250 TO 3040 Hz
⑥ RESPONSE BETWEEN TRANSMITTER INPUT AND RECEIVER OUTPUT ± 0.5 DB, FROM 360 TO 3040 Hz

USB UPPER SIDEBAND
LSB LOWER SIDEBAND
VF VOICE FREQUENCY
IF INTERMEDIATE FREQUENCY

Figure 2-1. Basic DCS HF Radio Circuit Block Diagram

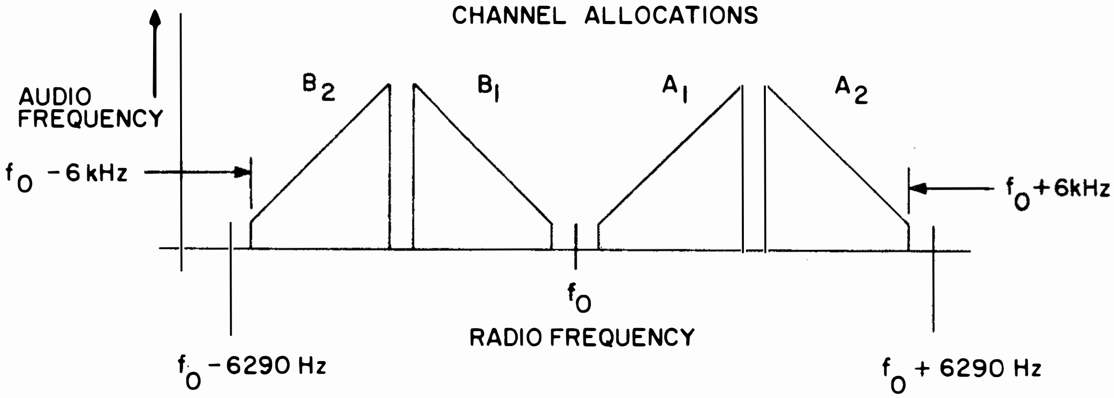


Figure 2-2. Independent Sideband Allocation

a. Circuit Functional Block Diagrams with Associated Equipment Selection Sheets. These functional block diagrams are being developed for each of the "basic types of circuits" (39 at present) used for Navy electronic equipment. The circled numbers appearing in each block on the functional block diagram refer to a specific "Equipment Selection Sheet"[1] keyed to that block. This sheet will provide a listing of every piece of equipment that could fill the requirement for that specific block on the functional block diagram and will include the technical parameters of each equipment. It will also indicate suitability classification levels of (1) planned standard, (2) preferred standard, (3) limited standard, (4) sub standard (substitute standard), (5) obsolescent and (6) obsolete.

b. Standard Blank Work Forms (Planning Aids). These forms provide a rapid means of compiling information such as jack assignments, cable designators, cable runs, equipment arrangement in standard cabinets, cable terminations, intermediate distribution frame (IDF) terminations and many other types of data. The planner merely fills in the required technical information.

c. Standard Installation Drawings. These drawings contain elementary wiring diagrams of electronic equipment in common use by the Navy, plus other pertinent information such as equipment outline and mounting dimensions, distribution frame terminations, a power cable chart and a bill of material. By selecting and reproducing the diagrams of the equipment to be installed, the planning engineer will eliminate a large amount of the drafting normally required.

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[1]Equipment selection sheets are not available at present but will be developed in the near future. It is also planned to "key" the functional block diagrams to the CORs which means that each COR line item will call out the associated functional block diagram.

2.3.1 Use of Standard Plans

The standard plan system is designed to lead the planning engineer to each logical step in the planning process. The suggested sequence of events in using the standard plans is as follows:

a. The COR line item will identify a functional block diagram within the standard plans program that will satisfy the requirements for the particular circuit.

b. The functional block diagrams, in turn, will identify specific equipment selection sheets from which equipment is selected to satisfy the requirement.

c. The equipment selection sheets, then, will identify the installation drawing numbers for the equipments selected.

The use of standard plans, to the maximum extent possible, is mandatory for planning shore electronic facilities installations. The objective is to promote standard configurations at all facilities and to reduce or eliminate redundancy in planning. Proposals to deviate from standard plans must be submitted to the Commander, Naval Electronics System Command for approval.

In certain extenuating circumstances the requirement to use standard plans may be waived. This applies primarily to a special or unique one-of-a-kind project accomplished by a private contractor. The equipment or system involved may be operational but still in a developmental state and may be supplied under an engineering furnish and install (EFI) contract that also includes engineering services and maintenance after acceptance. For example, a special purpose missile tracking radar or sonar detection system may fall in this category. Unless it is planned to procure more equipment of the the same kind, it may be more cost effective to accept the contractor's in-house equipment and installation design practices (commercial practices) rather than to develop standard plans. Trade-offs or compromises may also be expedient in order to meet an emergency situation or a committed operational date to satisfy a priority mission requirement.

2.3.2 Standard Plan Availability

The Naval Electronics Systems Command, Washington Division, has been designated as the repository for the general service masters of the standard plans. NAVELEX keeps these plans up to date and promulgates revised copies to the field. Standard plans for new equipments are procured with the equipment by a contractual provision to supply plans in accordance with MIL-D-1000/3(EC).

CHAPTER 3

COMMUNICATIONS CENTER

3.1 GENERAL

The communications center is the circuit-routing and message-processing portion of the Naval Communications Station. The physical areas of the communications center are those required for the introduction, processing, and receipt of communications traffic into and from the communications system. Figure 3-1 shows the division of a communications center into functional areas and indicates the flow of communications within the center. The various equipments are physically grouped in conformance with this functional concept.

3.2 TECHNICAL CONTROL

Technical control of the quality of all circuits is exercised in the technical control facility (TCF); however technical control functions are performed in three distinct areas:

- Technical Control Facility (Supervisory Area)
- Communications Security Equipment (CSE) area (Patch and Test, Crypto)
- Terminal Equipment area (Patch and Test, Terminals)

Technical control actions are performed by using patch and test facilities that allow technical control personnel to monitor and substitute equipment. Although patch and test facilities are included in all three areas, the overall technical control function is managed from the TCF where all circuit operational patching is done.

The definitions applicable to these functional areas are given in the following paragraphs.

3.2.1 Technical Control Facility (TCF)

The TCF area is the area in which there is installed circuit and channel patchboards, test equipment and monitoring facilities sufficient to permit a technical controller to:

a. Exercise technical coordination between the connecting external technical control(s), the maintenance element and the users.

b. Exercise technical direction, coordination and supervision over (1) transmission media at the super group, group and channel level, (2) interface equipment appearing in the patch and test facilities, (3) remote transmitter and receiver sites, (4) relay sites, and (5) those communications facilities at all directly connected user installations.

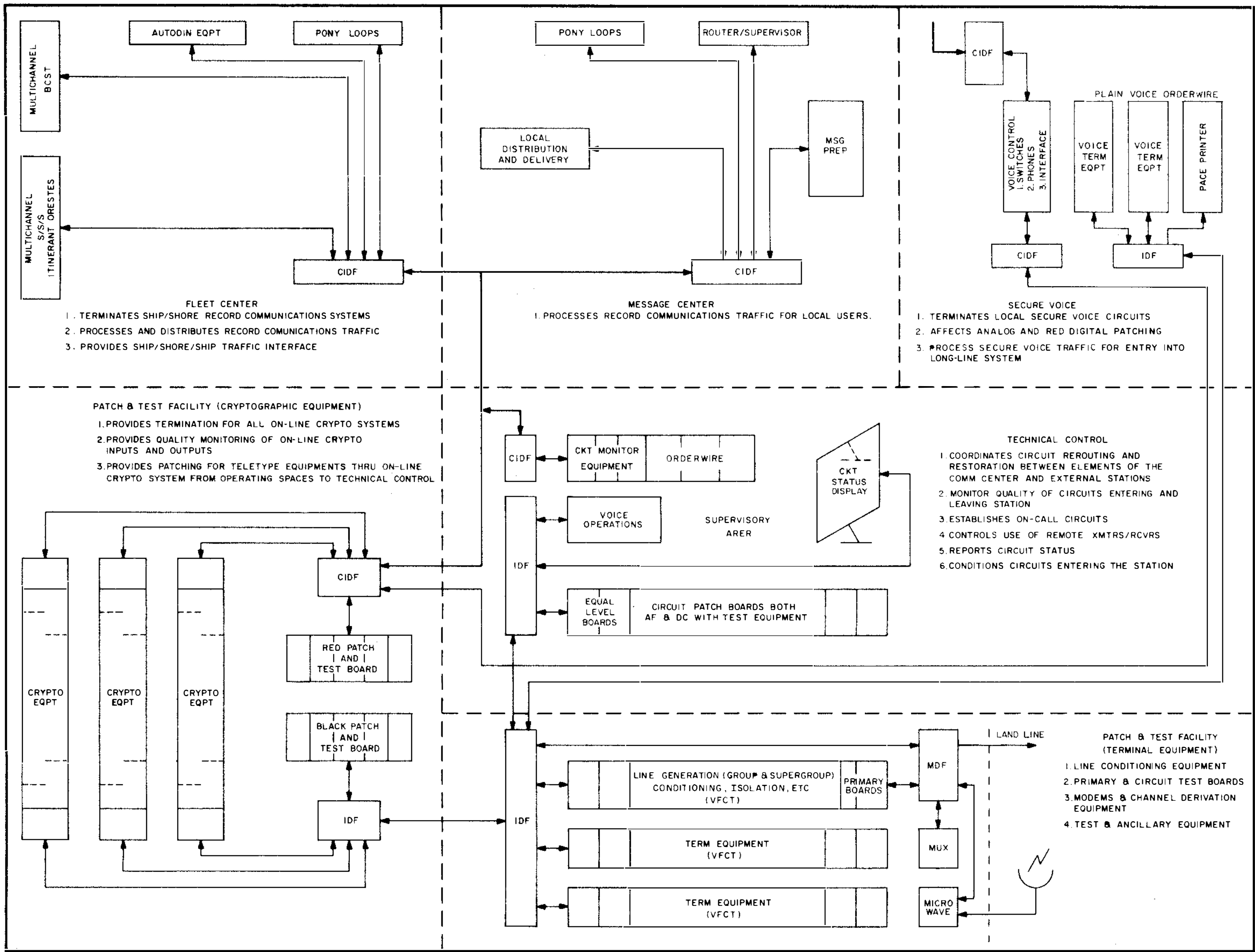


Figure 3-1. Functional Division Concept for Communication Center

c. Reroute and restore disrupted communications circuits at all levels of circuit capability in accordance with a pre-determined priority.

d. Establish on-call circuits.

e. Perform quality control tests on all circuits passing through the TCF.

f. Establish, activate or deactivate, rearrange, and discontinue circuits that enter and leave the station.

g. Report circuit status to proper management for record purposes.

3.2.2 Communications Security Equipment Area

The CSE area is the area that contains on-line cryptographic equipment with sufficient patchboard, test and monitoring equipment to permit personnel, under the direction of the technical control supervisor, to:

a. Isolate equipment troubles occurring in the CSE area.

b. Substitute equipments, channels and circuits within the CSE area.

c. Perform back-to-back and loop-patching of cryptographic equipments, channels and circuits for maintenance testing.

d. Perform monitoring and testing.

e. Perform crypto start and restart.

3.2.3 Terminal Equipment Area

The terminal equipment area is the area containing line conditioning equipment, modems and channel derivation equipment, primary test boards and circuit test boards to permit operating personnel, under the direction of the technical control supervisor, to:

a. Condition all lines to meet transmission criteria.

b. Restore (repair) disrupted communications links.

c. Replace and/or by-pass faulty terminal equipment.

3.2.4 Technical Control Task Breakdown

The breakdown of tasks within the three functional areas defined above is as follows:

a. Technical Control Facility (Supervisory Area). This area is operated as a limited access area with the capability of being temporarily unclassified with a minimum of effort in the event that personnel with a lesser clearance require access for maintenance or installation. Facilities included are:

(1) Covered orderwires
(2) Limited classified circuit monitoring and testing can be provided on a patch basis by the Patch and Test Facility (Communications Security Equipment)
(3) Circuit status display
(4) Unclassified voice control
(5) Transmitter and receiver control
(6) Equal level boards (DCA requirement)
(7) Digital and analog testing facilities
(8) Supervisory alarm control display center
(9) Supervisory control equipment for control of patch and test facilities
(10) DCS reporting capability

b. Communications Security Equipment Area. This is an exclusion area. Facilities included are:

(1) Black patchboards and test facilities to enable the back-to-back patching of crypto security equipment for maintenance.
(2) On-line crypto security equipment with associated ancillary units less remote control units normally associated with an operating position.
(3) Red patchboards separated from the black boards physically and electrically to prevent interconnection by patching, electrical induction or accidental interconnections.
(4) The required test equipment for the adequate maintenance and repair of low level devices, cryptographic equipment and the lines to the red processing equipment.
(5) Classified and unclassified digital test equipment.
(6) Narrative TTY monitors.

c. Terminal Equipment Area. This area is usually an unclassified space which terminates the connecting landlines or microwave links. Facilities included are:

(1) All line conditioning equipment
(2) All terminal equipment and channel derivation equipment
(3) Primary test boards
(4) Circuit test boards

3.3 PATCH AND TEST FACILITIES

Patch and test facilities are located in each of the above technical control areas to provide operational flexibility in the use of equipment and circuits. In general, these patch and test facilities allow equipment and circuit changes under the direction of the technical control supervisor as follows:

a. Patching of any circuit to any other compatible circuit

b. Patching of equipment to replace faulty equipment

c. Patching of test equipment to determine signal quality or circuit degradation

Figure 3-2 shows a typical circuit flow as it would be engineered through the patch and test facilities of the three technical control areas. The standard plans (see chapter 2) provide the specific routing criteria for each type of circuit as it is distributed through the communications center.

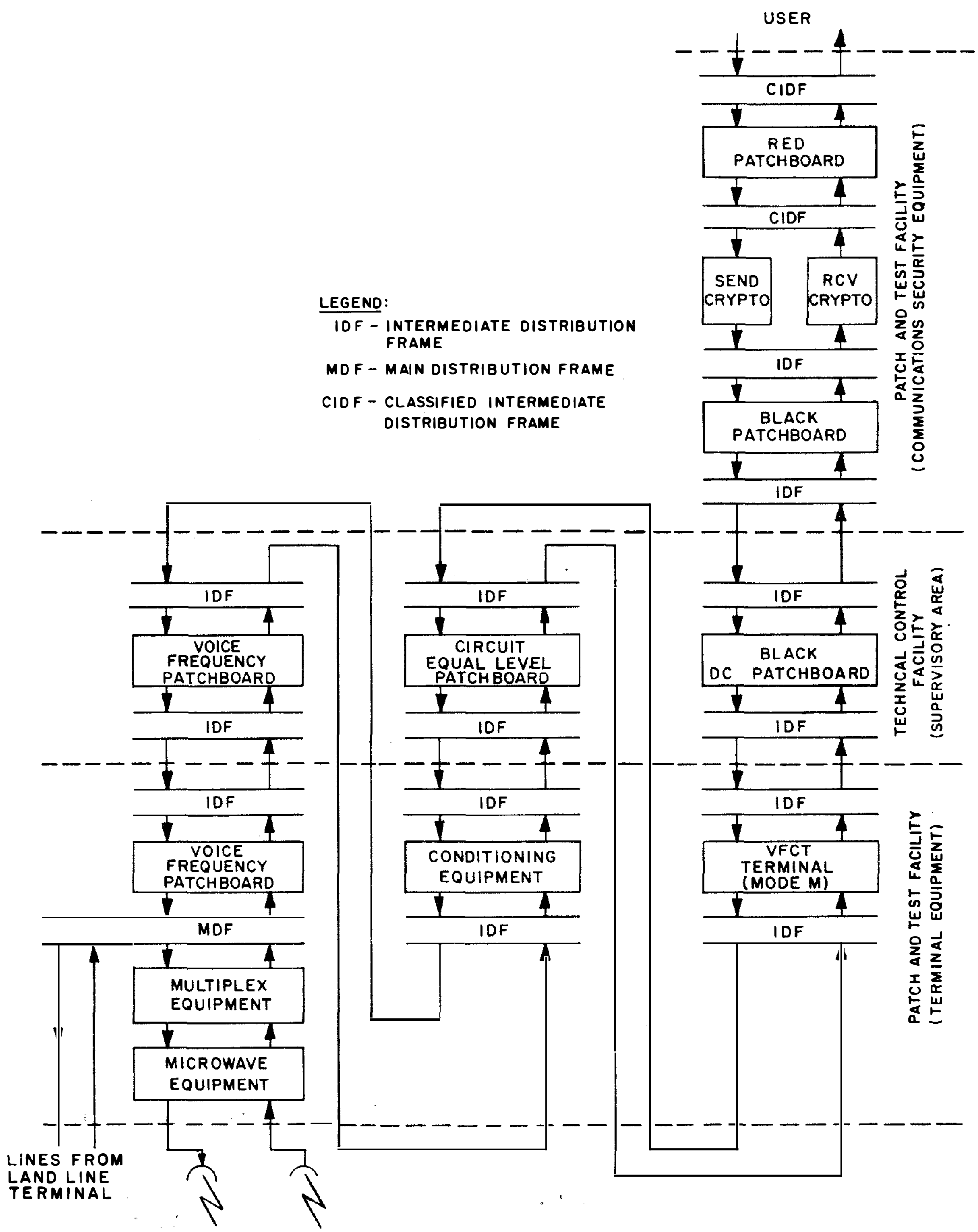


Figure 3-2. Typical Circuit Flow Through Communications Center Patching Facilities

3.4 PATCHBOARD EQUIPMENT

The patchboard equipment gives technical control personnel the flexibility to substitute and reconfigure the communications resources and they afford access for monitoring circuit quality. The patchboards are wired to attain the circuit flow prescribed by the NAVELEX standard plan for the system being implemented. The wiring criteria for these patchboards are described in chapter 9. In a patchboard each circuit appears at a jack which permits rerouting of the circuit through the use of patch cords. However, the design of the circuit requires that all jacks be the "normal through" type, so that patch cords are not required when the circuit is operating normally and without monitoring by general purpose test equipment. There are three basic types of patchboards used within the communications center:

a. Audio Patch Module, NAVELEX Standard Plan RW 10F2069C

b. DC Patch Module, NAVELEX Standard Plan RW 10F2383A

c. General Purpose Multi-circuit Patch Module, NAVELEX Standard Plan 0100305

These patchboards are packaged as modules with groups of jacks for 26 circuits in each module. This permits acquisition of patchboard equipment only as necessary to meet the existing circuit requirement and makes possible the addition of patchboards as the need arises.

The assignment of circuits and equipments to specific jacks in a patchboard is accomplished by cross connections at the distribution frame. All circuits that are accommodated by a particular patchboard are arranged in an order that closely fits the function for which the board is used. This arrangement permits quick location of a specific circuit or item of equipment for monitoring or troubleshooting.

Separate patchboards are provided for Red and Black information and these are separated by a minimum of 3 feet. The purpose of this separation is to prevent an operator from inadvertently patching a Red circuit to a Black circuit.

3.4.1 VFCT Patchboards

Voice-frequency carrier telegraph (VFCT) DC circuits are assigned to patchboards with the jack field arranged as shown in figure 3-3. A 104-circuit-capability is the maximum for a single equipment cabinet. When additional circuits are required, other equipment cabinets with patchboards are placed to the right and the system grouping is continued. VFCT DC patchboards are made up of the standard SB-3189A patch modules which are provided only as needed to satisfy the circuit requirement.

3.4.2 Hubber Unit Patchboards

The numerous inputs and outputs of the hubber unit and its broad range of capabilities dictate the representative arrangement of jacks illustrated by figure 3-4. In this configuration each module of the hubber unit requires four sets of jacks, and these sets appear on the patchboard consecutively from left to right.

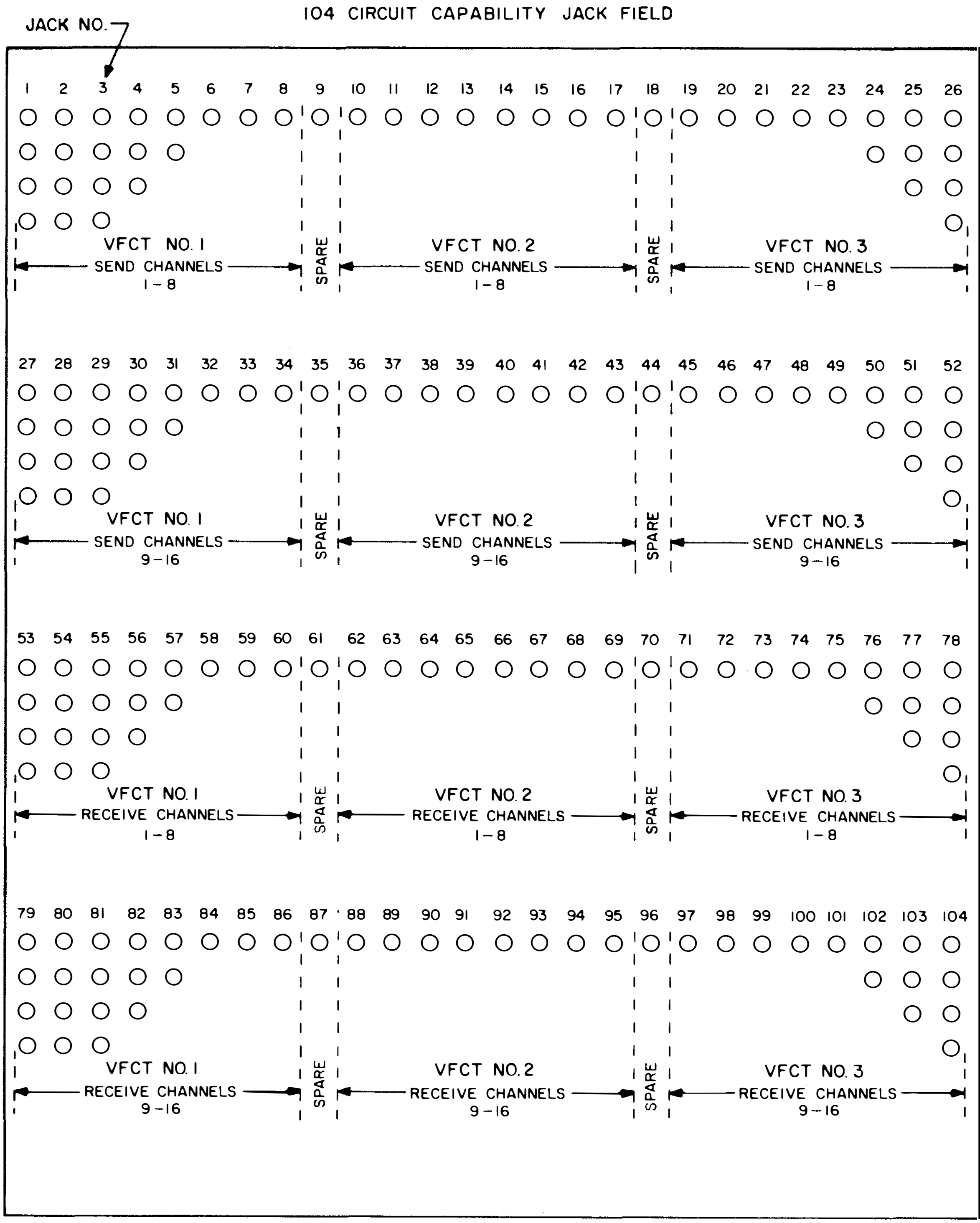


Figure 3-3. VFCT Jack Field Arrangement

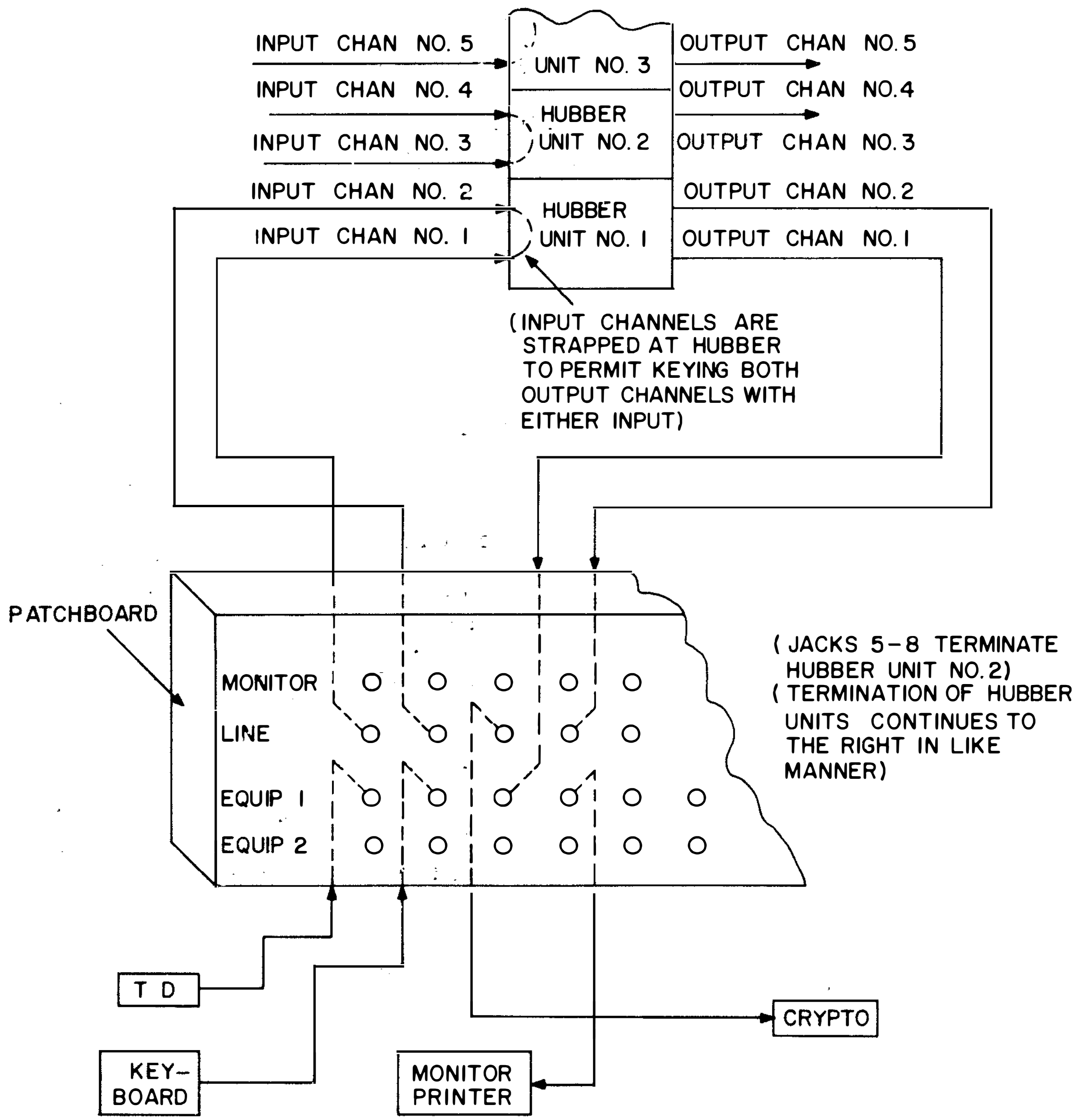


Figure 3-4. Hubber Unit Jack Field Arrangement

3. 4. 3. Audio Patchboards

The circuit layout of the audio-frequency patchboards is determined by their use. Where the patchboards are used to support intersite channels, the channels are grouped according to their receive or transmit function. Within a group, the channels will appear in consecutive order from left to right and top to bottom.

For small stations, both the transmit and receive channels will appear in the same cabinet and the receive channels will be positioned below their corresponding send channels. For large stations the receive channels will appear in adjacent cabinets.

3. 5 ORDERWIRE EQUIPMENT

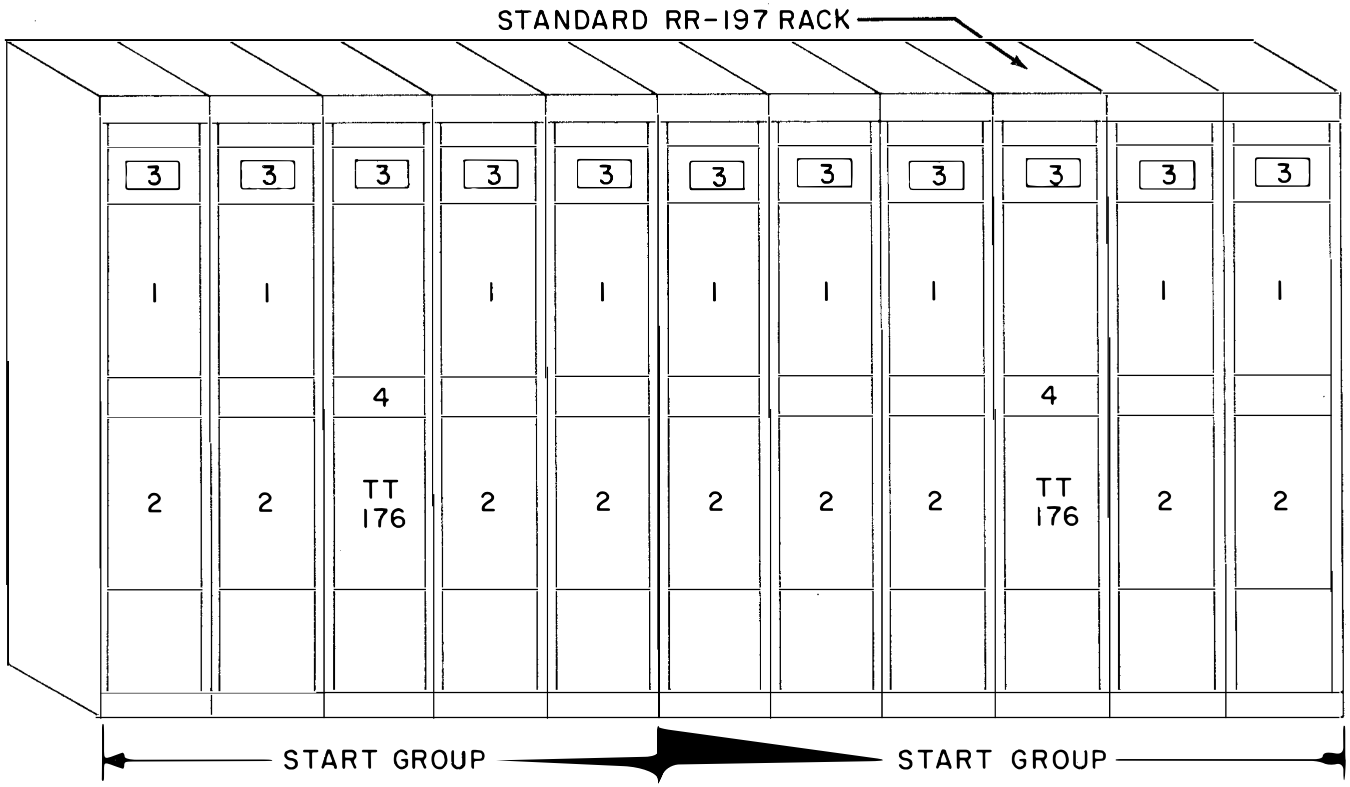
Orderwire circuits are used for the coordination of the communications resources of the Naval Communication Station and for the coordination of the communication circuits between stations. The terminal location for orderwire circuits is the technical control facility (supervisory area). The terminal device, telephone or teletypewriter, may be shared among several orderwire circuits, provided that each circuit includes an alarm to indicate an incoming call. The need for a continuous log or record of the information transmitted and received on an orderwire circuit must be considered when planning the types and the number of terminal devices to be installed. However, voice orderwire capabilities are not normally provided with record facilities.

3. 6 COMMUNICATIONS SECURITY EQUIPMENT

The communications security (COMSEC) equipment performs cryptographic functions to convert between Red and Black data. COMSEC equipment is installed in the communications security equipment area of the communications center and is arranged in racks by types. Operator access is a major consideration in placing the equipment. Since the COMSEC devices alert operators to alarm conditions by visual and audible means, the equipments should be visible from the Red and Black patchboards that are located with the COMSEC equipment. Teletypewriter equipment must be collocated with the cryptographic devices to aid in restarting. One restart teletypewriter is usually provided for each group of 5 cryptographic equipments. Refer to figure 3-5.

3. 7 TIME AND FREQUENCY STANDARD

A central time and frequency standard for the various equipments used throughout the communications center is being planned. Some existing systems generate 10-MHz, 1-MHz, and 100-kHz frequencies which are distributed to the equipments to control timing and to stabilize the frequency of modulation and demodulation equipment. However, the requirements for redundancy in the event of failure and for isolation of Red and Black data have not yet been fully defined for the time and frequency standard. When approved, the time and frequency standard will be installed in and operated as part of the technical control equipment. The output of the central time and frequency standard will be distributed through coaxial cables routed in the same trays with the signal cabling.



LEGEND:

1 - KWT-26
2 - KWR-26
3 - CARD HOLDER
4 - KW-26 SEL. SW. (START CONTROL)

Figure 3-5. Typical Arrangement for Cryptographic and Restart Equipment

3.8 AUDIO FREQUENCY INTERFACE EQUIPMENT

Most information sent from or received at the communication center is in the form of analog signals carried in a 300- to 3400-Hz band. The audio-frequency equipment provides the interface between the communications center and all landline, line-of-sight, cable, or other transmission means. Such equipment provides the equalization, attenuation, amplification, or other signal conditioning that is needed for the interface between the transmission means and the equipments of the communication center. These equipments are contained within the patch and test (terminal equipment) area. Refer to chapter 6 for a discussion of the link equipment used for intersite communications.

3.9 VOICE FREQUENCY CARRIER TELEGRAPH EQUIPMENT

The VFCT terminal equipment combines up to 16 separate teletype and digital DC signals into complex tones for radio transmission using a 3-kHz bandwidth. The terminal also separates a received 3-kHz complex tone signal into its individual DC signals. VFCT is the primary means of transmission for large-volume, long-haul traffic in the Navy.

The VFCT channel assignment, center, mark, and space frequencies for Navy tactical circuits are to be in accordance with tables 3-1 through 3-3. These tables were promulgated by message ALCOM 79, 1968. The ALCOM also requires that all VFCT channels use negative polarity (inverted or reverse) sensing. The communications center may use VFCT equipment to interface with systems other than Navy tactical systems. In this case VFCT channelization and frequency assignment would be determined on a special case basis.

The capability of monitoring the quality of the composite and individual signals may be incorporated within the equipment. In any case the monitoring equipment used operates in parallel with the functioning circuit, measures the distortion content, and must be capable of operating at the 37.4 to 150 baud rate. When automated monitoring equipment is employed, the circuit status display is located within the TCF supervisory area.

3.10 DIGITAL-DATA END-INSTRUMENT EQUIPMENT

Data terminals consist of input and output equipments, modulation and demodulation devices, and manual or automatic supervisory controls. The digital signals are received from and sent to the equipment by one or more of the methods listed in table 3-4. A terminal may also perform temporary storage, code format, and band conversion functions. Conversion of data between serial and parallel form, when required, is also a function of the data terminal.

The ability of the transmission means to pass the required data at the required rate is an important factor in planning the use of digital data equipment. Voice channels with a nominal 4-kHz bandwidth are used to interconnect data equipment. These voice channels are combined as required to provide a path of sufficient capacity to support the equipment data rate. Low speed, up to 150 bauds, requires only narrow-band channels. From 12 to 24 such narrow-band channels may be multiplexed over one voice channel. Medium speed, up to 2400 bauds, presently requires one voice channel. High speed, up to 5000 kilobits per second requires a large number of voice channels. Voice channels are usually arranged in groups (12 voice channels) and supergroups (5 groups) for multiplexing over broadband transmission links within the telephone network. One group will accommodate 40.8 kilobits per second.

Table 3-1. VFCT Channelization

CHANNEL DESIGNATION	MARK FREQUENCY (Hz)	CENTER FREQUENCY (Hz)	SPACE FREQUENCY (Hz)
1	382.5	425	467.5
2	552.5	595	637.5
3	722.5	765	807.5
4	892.5	935	977.5
5	1062.5	1105	1147.5
6	1232.5	1275	1317.5
7	1402.5	1445	1487.5
8	1572.5	1615	1657.5
9	1742.5	1785	1827.5
10	1912.5	1955	1997.5
11	2082.5	2125	2167.5
12	2252.5	2295	2337.5
13	2422.5	2465	2507.5
14	2592.5	2635	2677.5
15	2762.5	2805	2847.5
16	2932.5	2975	3017.5

Table 3-2. VFCT Channelization Using Diversity Spacing

CHANNEL DESIGNATION	MARK FREQUENCY (Hz)	CENTER FREQUENCY (Hz)	SPACE FREQUENCY (Hz)
1	1827.5	1785	1742.5
2	382.5	425	467.5
3	1997.5	1955	1912.5
4	552.5	595	637.5
5	2167.5	2125	2082.5
6	722.5	765	807.5
7	2337.5	2295	2252.5
8	892.5	935	977.5
9	2507.5	2465	2422.5
10	1062.5	1105	1147.5
11	2677.5	2635	2592.5
12	1232.5	1275	1317.5
13	2847.5	2805	2762.5
14	1402.5	1445	1487.5
15	3017.5	2975	2932.5
16	1572.5	1615	1657.5

Table 3-3. VFCT Channelization Using Twinning (Quadruple Diversity)

TWINNED CHANNEL DESIGNATION	TWINNED CHANNEL CENTER FREQUENCY (Hz)	NORMAL CHANNEL CENTER FREQUENCY (Hz)
1 (9)	1785	425
2 (10)	1955	595
3 (11)	2125	765
4 (12)	2295	935
5 (13)	2465	1105
6 (14)	2635	1275
7 (15)	2805	1445
8 (16)	2975	1615

Table 3-4. Digital Data Input And Output Methods

INPUT	OUTPUT
Keyboard	Page printer
Punched paper tape	Punched paper tape
Magnetic tape	Magnetic tape
Direct computer input	Direct computer output
Punched card	Punched card

Distribution of digital data throughout the communications center is accomplished via DC circuits using low-level polar signal loop voltage. The nominal low-level voltage and current for a "mark" is +6 ±1.0 volt, 0.001 ampere (max), and for a "space" is −6 ± 1.0 volt, 0.001 ampere (max). Low-level keying is specified for use within the communications center for both Red and Black circuitry. Red circuits carry, or are cleared to carry, classified plain-text traffic. Black circuits carry traffic protected by communications security (COMSEC) equipment or unclassified, plain-text traffic. Black DC circuits are currently distributed using high level neutral or polar current loops; however, communications centers using high-level loops are to be converted to low level. In a neutral circuit, the marking condition occurs when the signal loop is closed. The polar circuit reverses the current of the signal loop to differentiate between the marks and spaces. Positive voltage represents a mark and negative voltage a space. The current and voltage parameters for high level loops are listed in table 3-5. High level DC loops, usually neutral, may find continuing use at transmitting stations and for communications over small tributaries on a special case basis. Therefore the advent of low level Black systems may not entirely eliminate high level lines that must interface with other Navy or public carrier lines. Western Union may use 130-volt 20-milliampere polar keying, while phone lines frequently use both a positive and a negative 130-volt battery for the two sides of the line, giving an effective voltage of 260 volts.

Table 3-5. High-Level Signal Loop Parameters

	POLAR*	NEUTRAL*
Loop Current	20 mA ±10%	60 mA or 20 mA ±3%
Loop Voltage	+60 V ±2%, -60 V ±2%	130 V ±2%
Termination Impedance	150 ohms	150 ohms

*Peak voltage is limited to 150 volts

3.10.1 Automatic Digital Network (AUTODIN)

The AUTODIN digital subscriber terminal is installed within the communications center. Figure 3-6 shows the family of systems being supplied and their major components and capabilities. Standard plans are issued to insure standardization of installation and arrangement. These plans show the permissible equipment arrangements from which the best one for the location is selected. Plan RW 10 F 2262 is the standard plan for the AN/FYA-71(V)2 system.

SET NOMENCLATURE	ORIGINAL CONFIGURATION CODE	CAPABILITY				INPUT/OUTPUT DEVICES SUPPLIED										
		150 BAUD PAPER TAPE	1200 BAUD PAPER TAPE	300 BAUD PUNCHED CARD	1200 BAUD PUNCHED CARD	COMMON CONTROL UNIT C-8120(P)/G	CONTROL-KEYBOARD C-7185/G	READER, PUNCHED CARD RP-152/G	READER, PUNCHED TAPE RP-154(P)/G	PAGE PRINTER RP-157/G	CARD PUNCH, LOW SPEED RO-313/G (ON LINE)	CARD PUNCH, LOW SPEED RO-313/G (OFF LINE)	CARD PUNCH, HIGH SPEED RO-312/G	PAPER TAPE PUNCH, LOW SPEED RO-315/G (ON LINE)	PAPER TAPE PUNCH, LOW SPEED RO-315/G (OFF LINE)	PAPER TAPE PUNCH, HIGH SPEED RO-314/G
AN/FYA-71(V)1	AA	○				○	○		○	○				○	○	
AN/FYA-71(V)2	AB	○		○		○	○	○	○	○	○	○		○	○	
AN/FYA-71(V)3	AE		○			○	○		○	○					○	○
AN/FYA-71(V)4	BB				○	○	○	○		○		○	○			
AN/FYA-71(V)5	BC			○		○	○	○			○	○				
AN/FYA-71(V)6	BE		○		○	○	○	○	○	○		○	○		○	○

Figure 3-6. DSTE Set Capabilities and Concepts

3.10.2 Teletypewriter Equipment

Teletypewriter equipment uses a five-unit code composed of marks and spaces. Different groupings of the units represent a specific printed character. Figure 3-7 shows the details of the standard teletypewriter code and the various code unit lengths in use. The Navy normally uses a 7.42 unit code with a signal length of 13.47 milliseconds for a 100 word-per-minute teletypewriter circuit. Slower speed circuits are also in existence for special purpose use.

3.11 AUTOMATIC SECURE VOICE COMMUNICATIONS

The Automatic Secure Voice Communications (AUTOSEVOCOM) System is a worldwide voice network that provides four wire secure and non-secure voice quality communications between designated military commands (subscribers). AUTOSEVOCOM interconnects locations with either narrow-band (NB) or wide-band (WB) communications channels. A narrow-band channel will support communications at a rate of 2400 bits per second and can be transmitted over a 3-kHz HF radio circuit. The wide-band circuit supports communications at 50 kilobits per second and is transmitted by wire line or microwave means.

The Navy Communications Center supports the system by operating subscriber terminals that interface between the worldwide system and the local subscriber or an HF radio circuit (Steam Valve) which in turn connects with the subscriber. The subscriber is homed to the worldwide system either on a secure voice switch or directly on an Automatic Voice Network (AUTOVON) switch or to a Joint Overseas Switchboard (JOSS). The AUTOSEVOCOM equipment provides for WB secure voice communications between local subscribers and enables local subscribers to establish long distance voice calls with other military commands. The AUTOVON switch provides NB, long-haul communications for subscribers that cannot be economically served by WB equipment. The majority of long-distance calls are routed via the AUTOVON system. NB and WB circuit parameters for AUTOSEVOCOM are prescribed by the latest issue of DCAC 310-130-1 — "Processing of Telecommunications Service Requests."

Simplified typical single line circuit flow diagrams for the AUTOSEVOCOM system within the communications center are shown in figures 3-8 and 3-9. The minor relay AUTOSEVOCOM interface (figure 3-8) is the system used when NB capabilities will satisfy the operational requirement. When a major relay with both NB and WB capabilities is required, a system similar to that shown in figure 3-9 is used. Typical floor plans for AUTOSEVOCOM systems are contained in the latest issues of DCAC 300-S175-3 through 6. Controlling criteria for the overall system are contained in the latest issues of the following publications:

- DCAC 300-S175-3 through 7
- DCAC 310-S70-12
- DCAC 310-130-1
- DCAC 370-S185-9
- DCAC 370-S185-10

CHARACTERS LOWER CASE	UPPER CASE COMM	UPPER CASE WEATHER	CODE SIGNALS START	1	2	3	4	5	STOP	CCITT NO. 2 UPPER CASE*	PERFORATED TAPE
A	–	↑		▧	▧				▧		O O o
B	?	⊕		▧			▧	▧	▧		O o O O
C	:	○			▧	▧	▧		▧		O o O O
D	$	↗		▧			▧		▧	WRU	O o O
E	3	3		▧					▧		O o
F	!	→		▧		▧	▧		▧	UNASSIGNED	O o O O
G	&	↘			▧		▧	▧	▧	UNASSIGNED	O o O O
H	STOP	↓				▧		▧	▧	UNASSIGNED	o O O
I	8	8			▧	▧			▧		O o O
J	'	↙		▧	▧		▧		▧	AUDIBLE SIGNAL	O O o O
K	(	←		▧	▧	▧	▧		▧		O O o O O
L	)	↖			▧			▧	▧		O o O
M	.	.				▧	▧	▧	▧		o O O O
N	,	⦷				▧	▧		▧		o O O
O	9	9					▧	▧	▧		o O O
P	0	0			▧	▧		▧	▧		O o O O
Q	1	1		▧	▧	▧		▧	▧		O O o O O
R	4	4			▧		▧		▧		O o O
S	BELL	BELL		▧		▧			▧	' (APOSTROPHE)	O o O
T	5	5						▧	▧		o O
U	7	7		▧	▧	▧			▧		O O o O
V	;	⦶			▧	▧	▧	▧	▧	=	O o O O O
W	2	2		▧	▧			▧	▧		O O o O
X	/	/		▧		▧	▧	▧	▧		O o O O O
Y	6	6		▧		▧		▧	▧		O o O O
Z	"	+		▧				▧	▧	+	O o O
BLANK		–						▧	▧		o
SPACE						▧			▧		o O
CAR. RET.							▧		▧		o O
LINE FEED					▧				▧		O o
FIGURES				▧	▧		▧	▧	▧		O O o O O
LETTERS				▧	▧	▧	▧	▧	▧		O O o O O O

NOTE: UPPER CASE H (COMM) MAY BE STOP OR #

WORDS PER MINUTE	UNIT CODE	SIGNAL LENGTHS IN MILLISECONDS STANDARD SPEED							TOTAL MILLISECONDS PER CHARACTER	OPERATIONS PER MINUTE
40	7.42	33	33	33	33	33	33	47	245	240
57	7.96	22	22	22	22	22	22	43	175	342 ①
60	7.42	22	22	22	22	22	22	31	163	368
62.5	7.27	22	22	22	22	22	22	28	160	375 ②
65	7.00	22	22	22	22	22	22	22	154	390 ③
66.7	7.50	20	20	20	20	20	20	30	150	400 ④
67.3	7.42	20	20	20	20	20	20	28.4	148.4	404 ⑤
75	7.42	18	18	18	18	18	18	25	133	460
100	7.42	13.5	13.5	13.5	13.5	13.5	13.5	19	100	600
106	7.00	13.5	13.5	13.5	13.5	13.5	13.5	13.5	94	636

▧ MARKING PULSE

☐ SPACING PULSE

* THIS COLUMN SHOWS ONLY THOSE CHARACTERS WHICH DIFFER FROM THE AMERICAN VERSION.

① USED WITH CRYPTO
② USED WITH CRYPTO AND AN/FGC-5
③ USED WITH WESTERN UNION CIRCUITS
④ USED WITH BRITISH GPO TELEGRAPH
⑤ AMERICAN EQUIVALENT OF EUROPEON STANDARD.

Figure 3-7. Characteristics Associated with the Teletypewriter Code

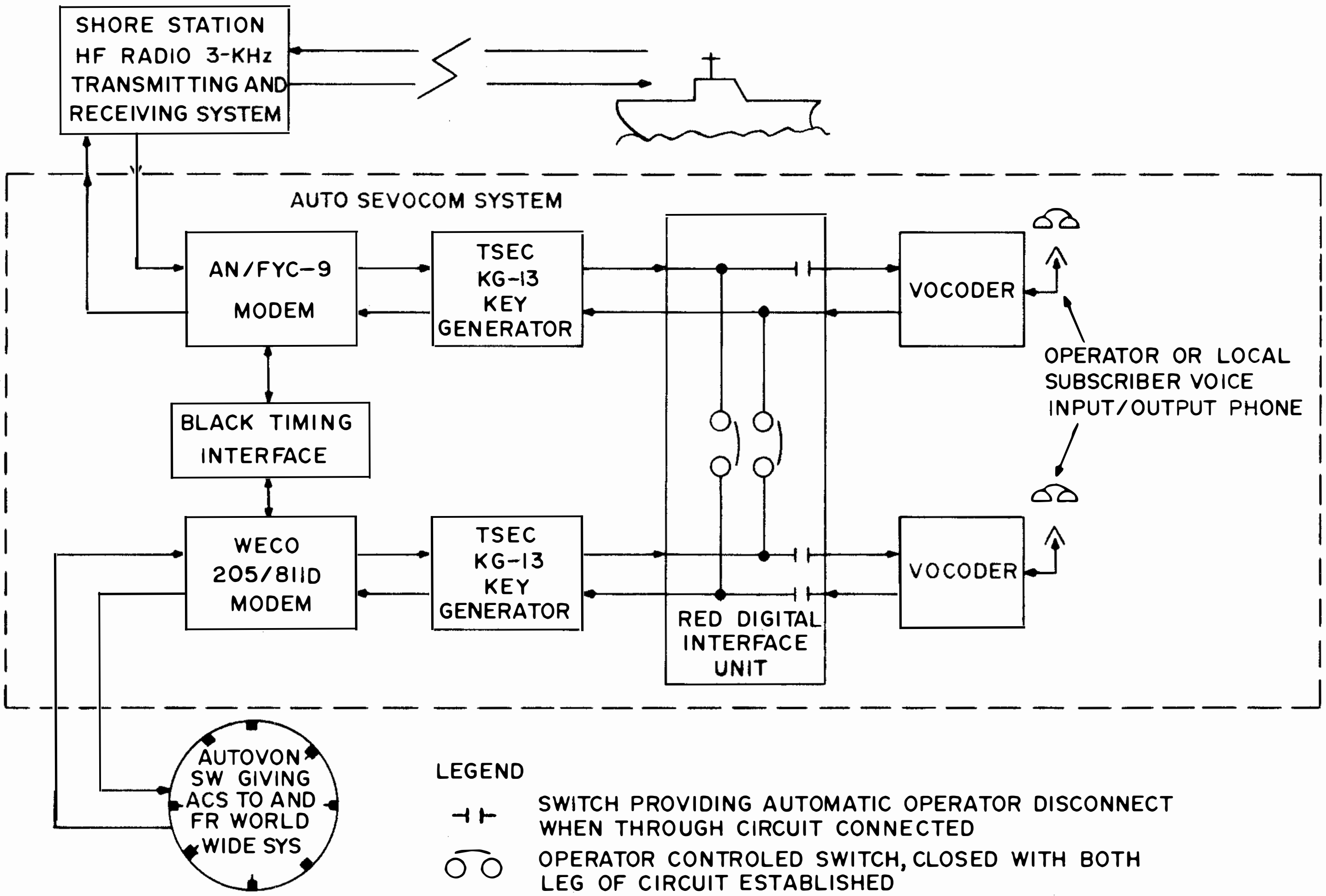
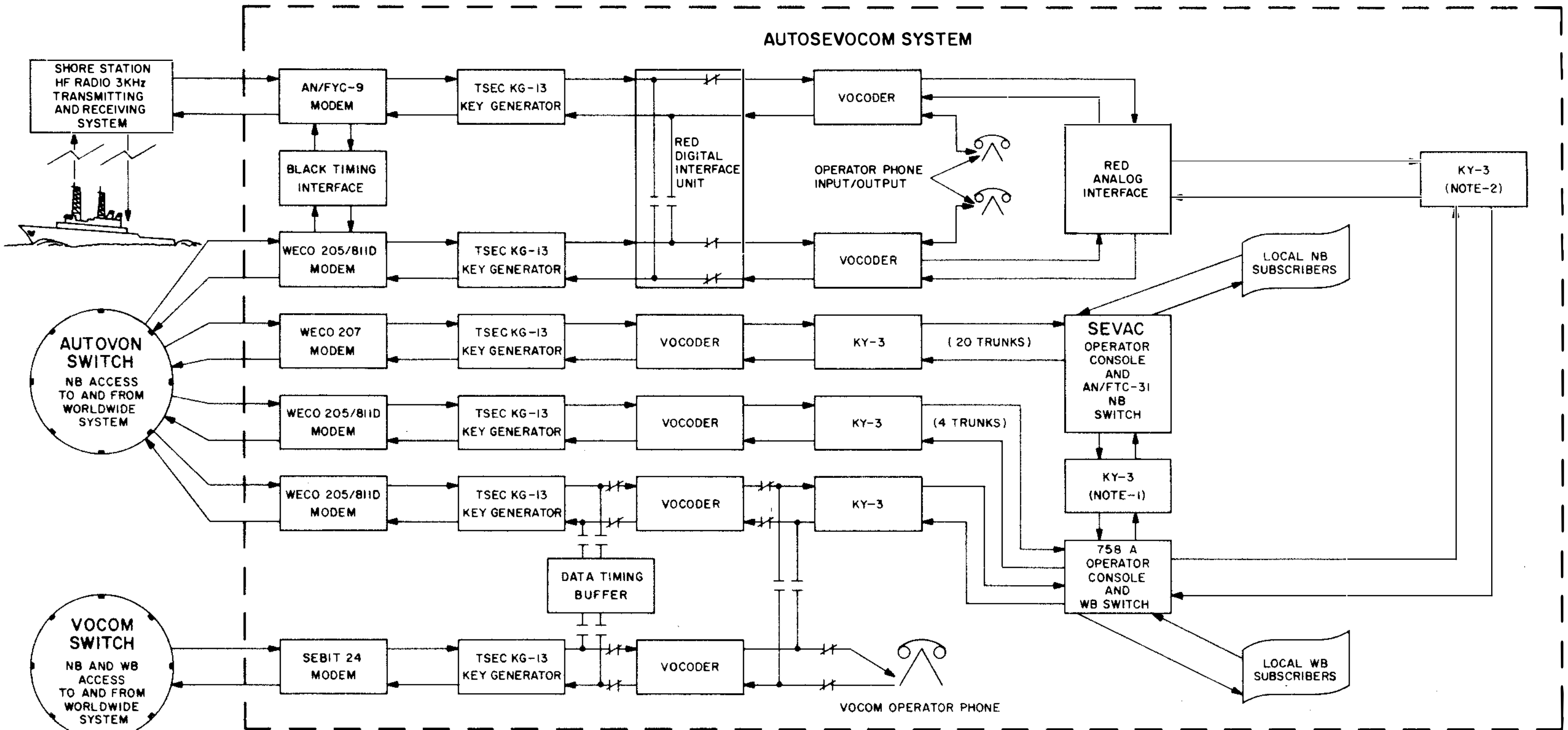


Figure 3-8. Minor Relay AUTOSEVOCOM Narrow-Band Interface



NOTES:

1. FOR 758 A OPERATOR'S USE WITH AN/FTC 31 SUBSCRIBERS OR USED ON TRUNK CIRCUITS FOR CHECKING QUALITY OF THE NARROW BAND TRUNK BEFORE COMPLETING A CALL FROM WB TO NB.
2. CALLS ACCEPTED FROM AN/FTG-31 OR 758 A SUBSCRIBERS, CALLS TO AN/FTG-31 OR 758 A SUBSCRIBERS MUST BE ROUTED THROUGH AUTOVON.

LEGEND:
NORMALLY OPEN
NORMALLY CLOSED

Figure 3-9. Major Relay AUTOSEVOCOM Interface

3.12 CABLING AND DISTRIBUTION FRAMES

The controlling criterion for the planning and installation of cabling and distribution frames in the communications center is the separation of circuits carrying Red information from those carrying Black information. Refer to the latest issue of NAVELEX Instruction 011120.1 — "Shore Electronics Engineering Installation Guidance for Equipments and Systems Processing Classified Information."

3.12.1 Distribution Frames

Distribution frames are used to terminate cabling from equipments, patchboards, and battery sources. A distribution frame is also used to serve as a central point for the exit and entrance of all communications circuits concerned with the mission of the communications center. The general types of frames and their wiring criteria are discussed in chapter 9. As a general rule distribution frames are located near the patchboards they terminate to minimize the length of cable runs.

3.12.2 Cabling

Cabling within the communications center is to be routed between equipments in a manner that presents a neat appearance and is compatible with the operational use of the system. Conduit and duct systems have been used in the past; however, such systems are not specifically required. See figures 3-10 and 3-11 for examples of such ducting systems. Systems supported from the overhead are preferred. Systems within raised flooring are authorized on a special case basis only.

The following general criteria apply to the cabling within the communications center:

a. One overall non-ferrous shield protected by an insulating sheath is the minimum shielding requirement for cables carrying Red information.

b. Individual non-ferrous shielded pairs of wire within a cable which is protected by an overall non-ferrous shield is required only on a special case basis as determined by the system engineering design requirements.

c. Non-ferrous shields on cables should be broken by termination at a distribution frame before the cable leaves a Red information area.

d. Low-level signal and control cables need not be encapsulated within a ferrous duct or distribution system.

e. High-level signal and control cables carrying Red information should be encapsulated within a ferrous duct or distribution system.

f. Spare conductors within a cable are to be grounded at the appropriate distribution frame serving the particular cable.

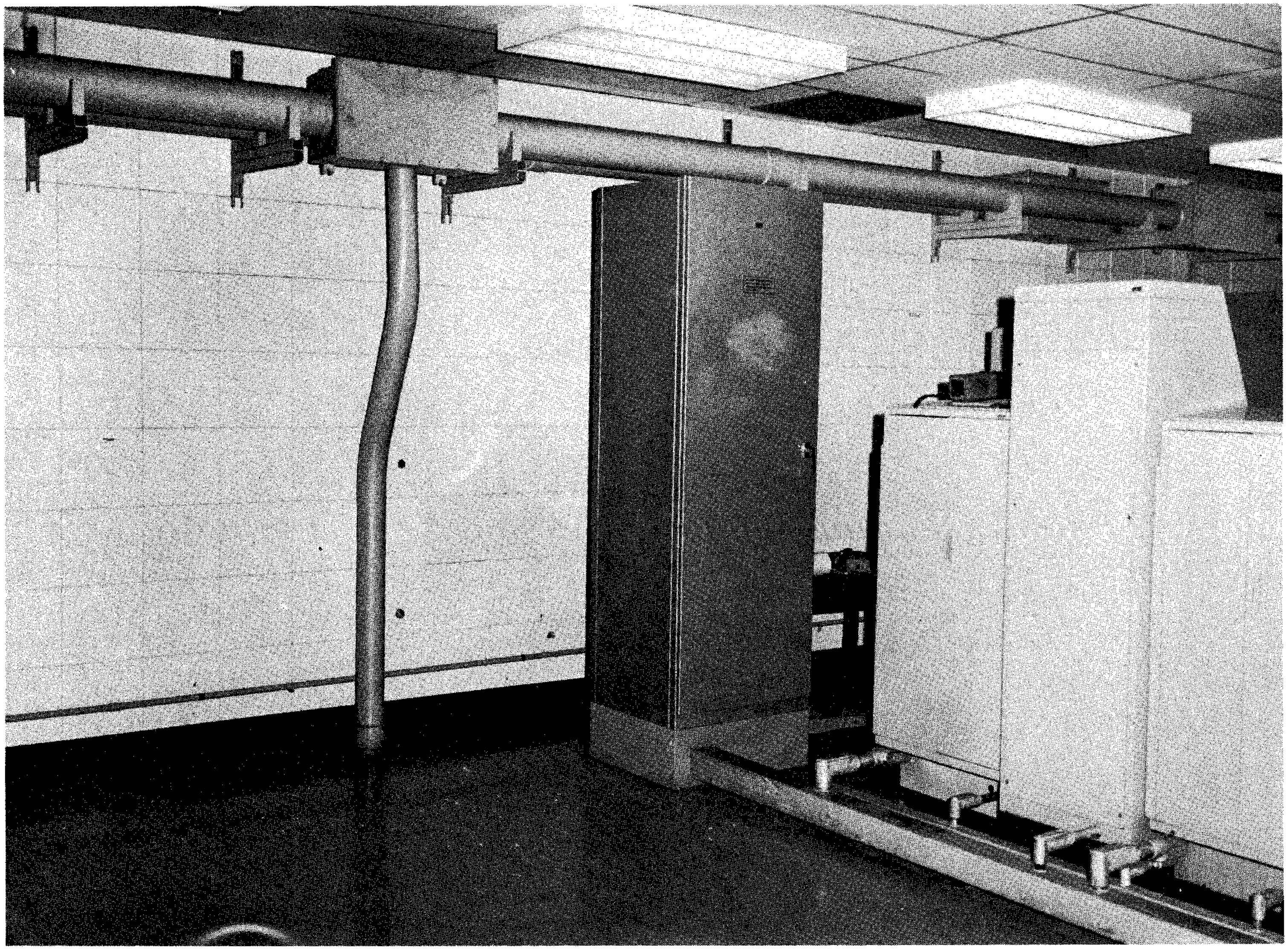


Figure 3-10. Typical Installation, Overhead Ducting

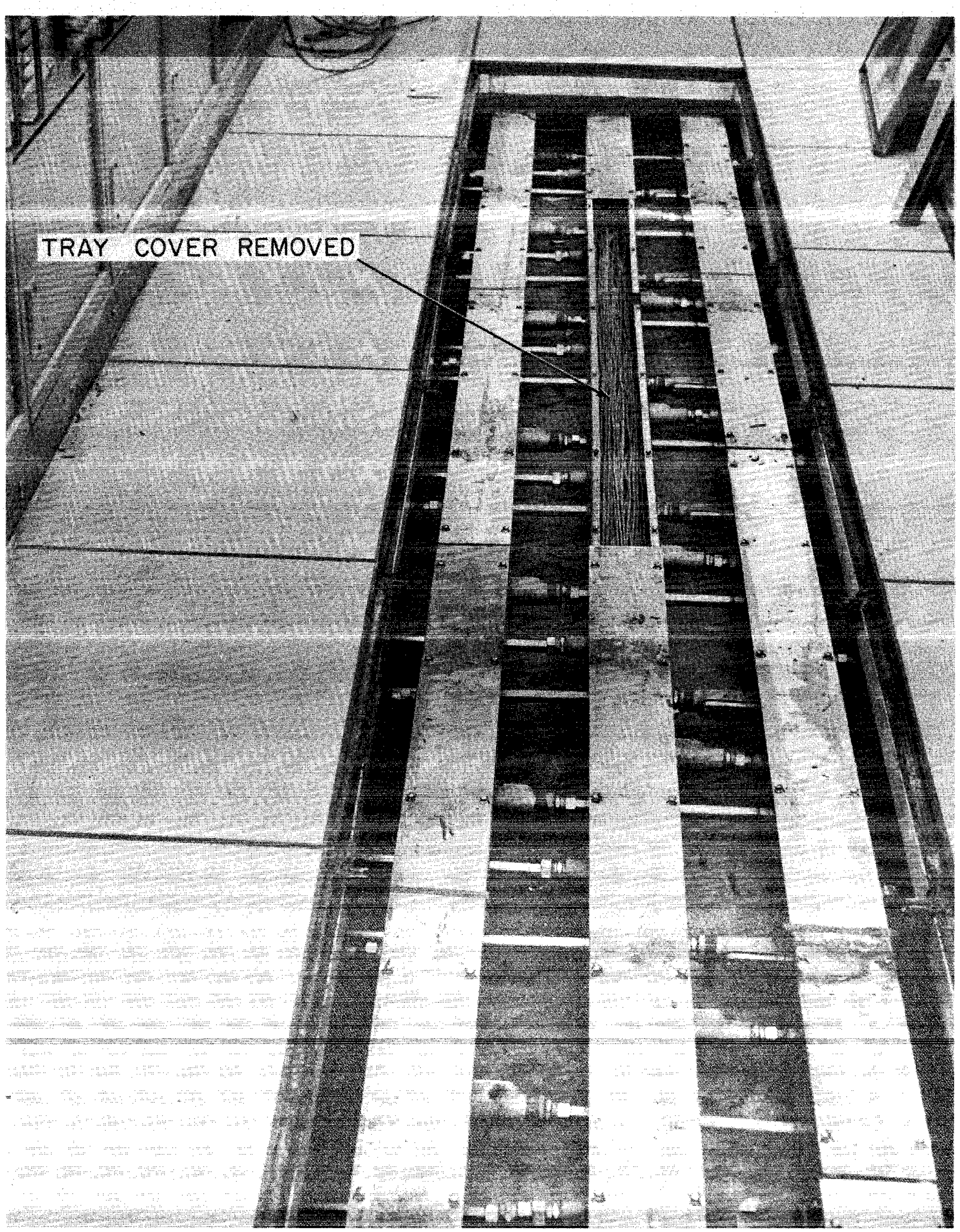


Figure 3-11. Typical Installation, Raised Flooring Ducting

3.13 CONSTRUCTION AND INSTALLATION

Permanent communications center buildings are constructed of masonry and concrete and may consist of more than one floor. Semi-permanent construction (transportable) has been used also, and such stations are discussed in chapter 13. The primary consideration in building construction is maximum operational efficiency. An example of a typical communications center layout is shown in figure 3-12 and the general building requirements for communications stations are discussed in chapter 7. The following subparagraphs provide specific building criteria for the communications center building.

3.13.1 Building Features

a. Spaces containing computers will normally have raised flooring and shall not contain provisions for cable trays.

b. Cable vaults are not normally included in communications center buildings.

c. A separate room is required for microwave system battery power supplies.

d. A shielded mainten nce ship is not normally required. Shielded rooms are provided only on a special case basis.

e. Physical security requirements applicable to building construction are stated in the lastest NAVELEX Instruction 011120.1.

3.13.2 Grounding

The communications center building does not require special grounding or bonding for its structural members. One grounding system is required for personnel and equipment protection and a second grounding system is required to ground the signal circuits.

The personnel and equipment protective ground system is the AC protective ground distribution, described in chapter 12, paragraph 12.6.1. This ground distribution is basically the green wire protective ground which is carried to each equipment along with the power feeders. The earth ground connection point for the AC ground distribution system must comply with the provisions of article 250-84 of the National Electrical Code and therefore, must not present more than 25 ohms to ground.

The governing criteria for the grounding system to be used as the signal ground are contained in NAVELEX Instruction 011120.1. The following general requirements must be met when engineering a signal ground system.

a. The signal ground system may have its own ground connection point. NAVELEX Instruction 011120.1 specifies the type of ground connection to be used for both large and small systems.

b. Separate ground distribution systems are required for Red and Black signal grounds. NAVELEX Instruction 011120.1 specifies when and where these two systems are to be interconnected.

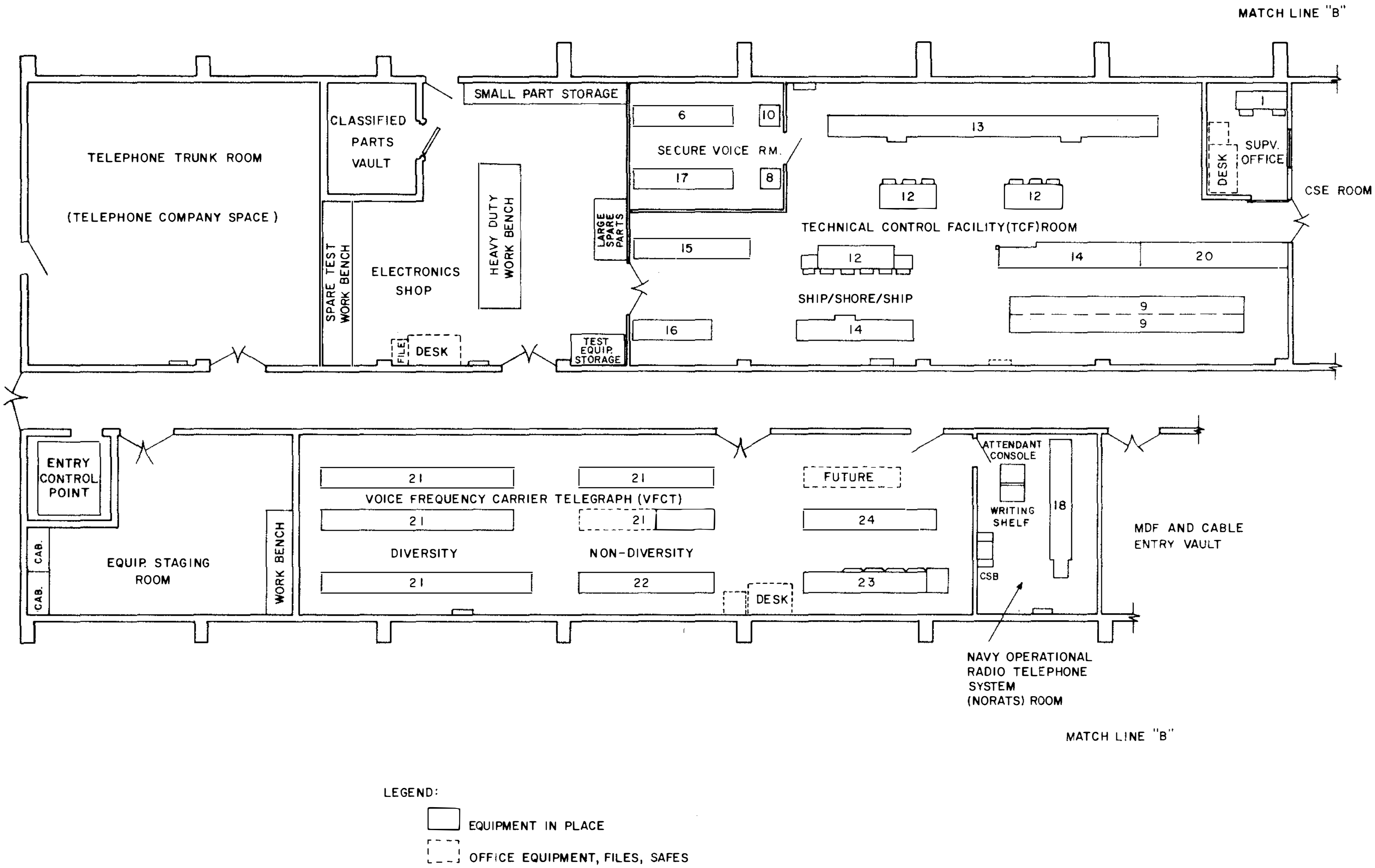


Figure 3-12. Typical Communications Center Layout (Sheet 1 of 3)

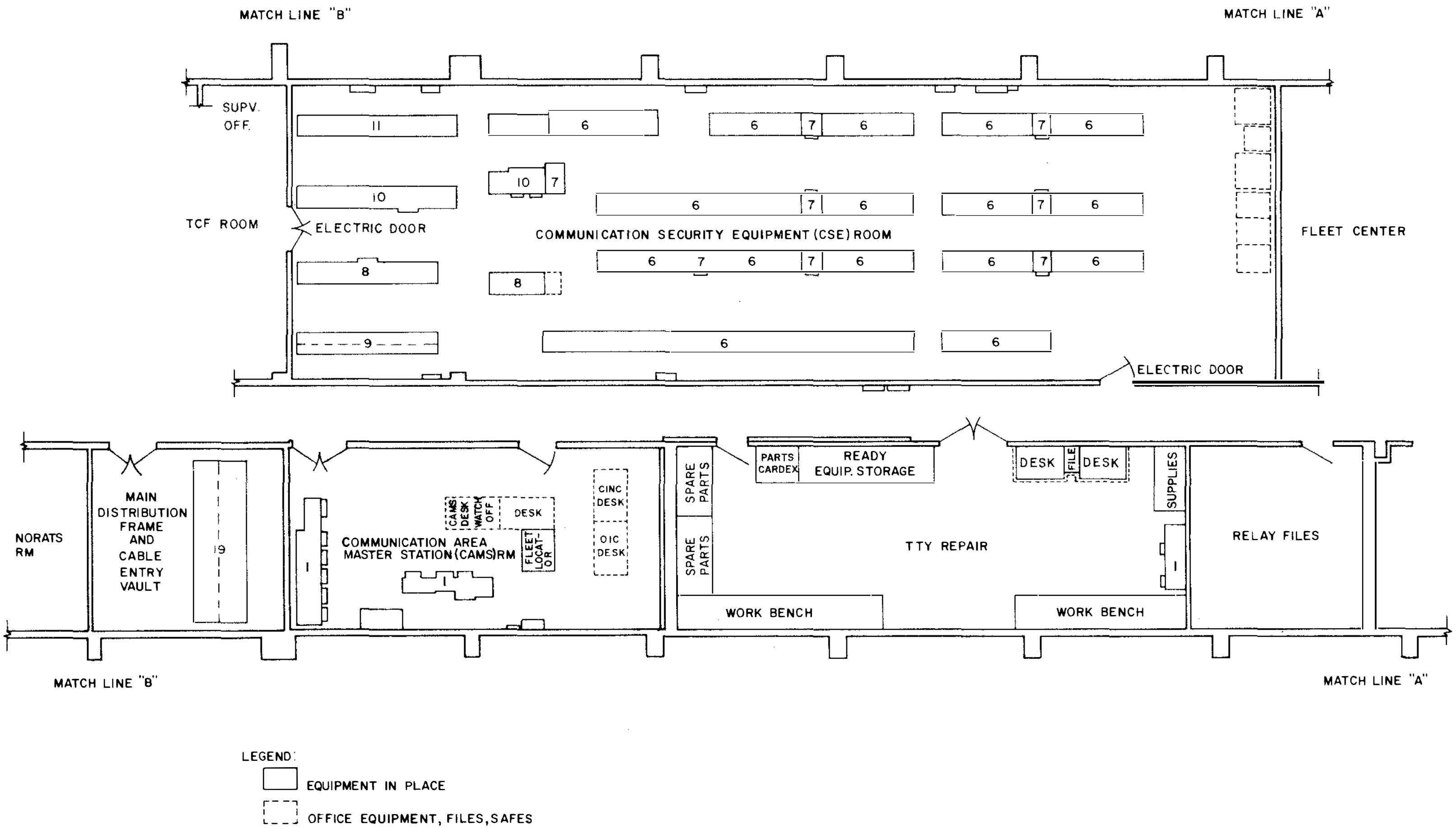
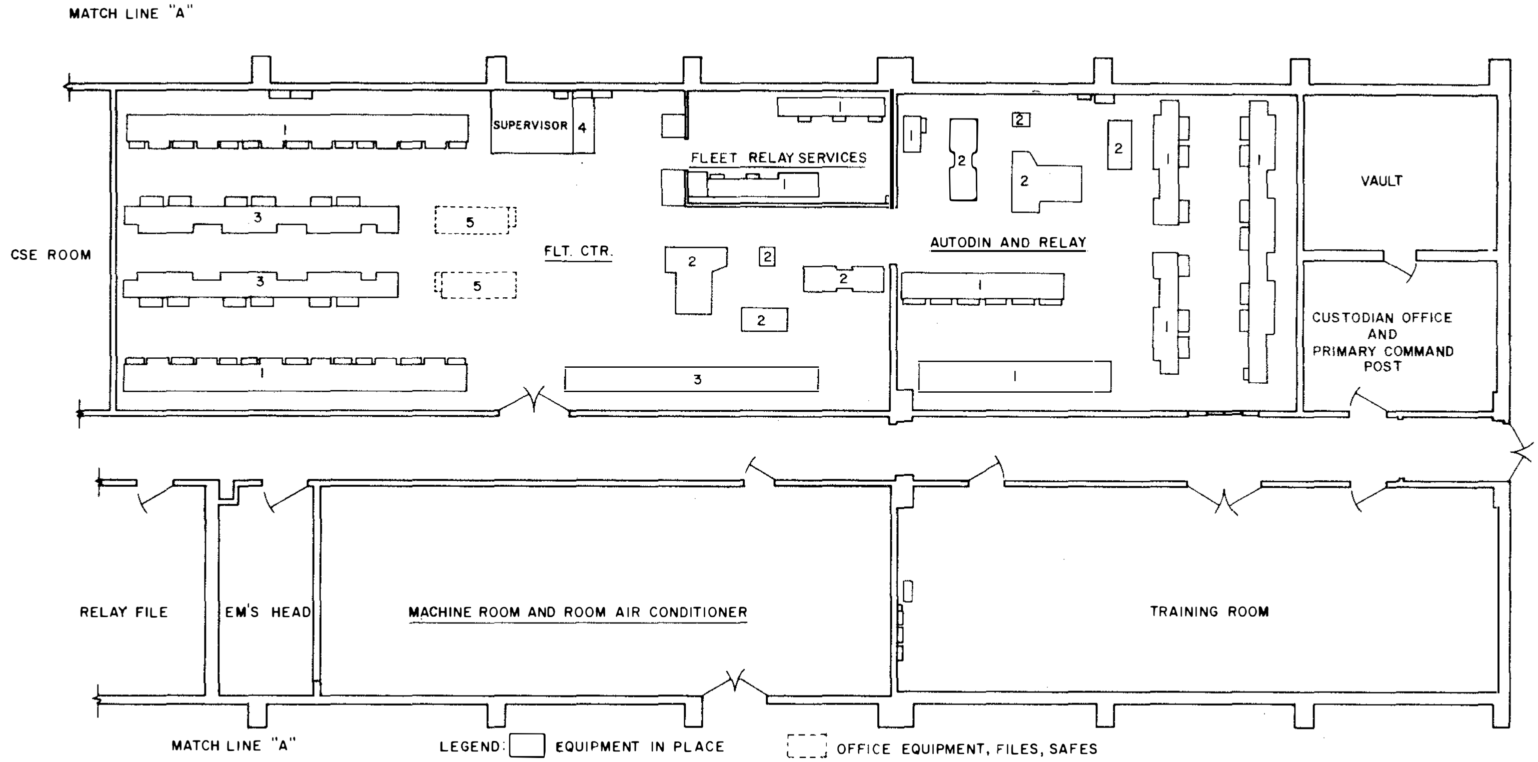


Figure 3-12. Typical Communications Center Layout (Sheet 2 of 3)



LEGEND:

1. TTY EQUIP
2. ADP EQUIP
3. TAPE READERS & PERFORATORS
4. HEADING SNATCHER
5. FUTURE EQUIP SPACE
6. COMSEC EQUIP
7. MONITOR & TEST EQUIP
8. BLACK PATCHBOARD & MONITOR POSITION
9. IDF
10. RED PATCHBOARD & MONITOR POSITION
11. CIDF
12. ORDERWIRE MONITOR EQUIP.
13. AUDIO FREQUENCY PATCHBOARDS & TEST EQUIP.
14. DC PATCHBOARD, & TEST EQUIP
15. DC POWER SUPPLY & ALARMS
16. ISOLATION RELAYS
17. VOCODER EQUIP
18. TELEPHONE TERMINAL & TEST EQUIP
19. MDF
20. INTERSITE LINK PATCHBOARD
21. VFCT TERMINAL EQUIP
22. MICROWAVE TERMINAL EQUIP
23. VOCODER MODEMS
24. AUTODIN TERMINAL SYSTEMS

Figure 3-12. Typical Communications Center Layout (Sheet 3 of 3)

3.13.3 Building Electrical Power

The primary power for the communications center is usually supplied by a commercial power company. An emergency power source may be provided to satisfy operational reliability requirements. The electrical power requirement for additional capabilities or for a new facility is stated in the BESEP for the use of the Naval Facilities Engineering Command (NAVFAC) Engineering Field Division (EFD). The following factors are applicable to the communications center power system:

a. No-break power (Class D) is provided for designated equipments. These equipments usually include the synchronous communications security equipments.

b. All communications equipment not connected to no-break power will be fed from the technical load bus.

c. The technical load bus may be subdivided into a critical technical load and a non-critical technical load. This will permit orderly restoration of power in the event of failure and will make load shedding possible in the event of power shortages.

d. Separate circuit breakers are required at the power distribution panel for each equipment rack or cabinet.

3.13.4 Equipment Arrangement

Efficiency is the primary consideration for locating equipment in the operations area. The general rule is that equipments used to perform the same or similar function are grouped together. The floor space to be provided for equipment access is governed by the matrix shown in figure 3-13. The criteria presented in this matrix were developed through application of the provisions of MIL-STD-803A — "Human Engineering Design Criteria for Aircraft, Missile, and Space Systems Ground Support Equipments." In cases not covered by the matrix, the minimum front clearance for operational equipments is 4 feet. Where two lines of similar equipment are operated, the minimum clearance is 6.4 feet between the two lines. The minimum rear access for equipments is determined by the width of the doors and access panels when extended perpendicular to the rear face, but in no case should the rear clearance be less than 18 inches for equipments requiring rear access.

3.13.5 Siting

The communications center building is physically separated from other station buildings such as power generating plants and living quarters. Also, to reduce to a minimum the possibility of mutual interference, the communications center is separated from other portions of the communications station as shown in table 3-6.

Item		DC PATCHBOARD LINE	VF PATCHBOARD LINE	ORDERWIRE LINE	TTY PACKAGE EQUIPMENT	CRYPTO LINE	FGC-73 CONSOLE	FGC REMOTE READER	FGC BRPE	TERMINAL EQUIPMENT	MANUAL PROCESS DESK	OUTSIDE BULKHEAD	THOROUGHFARE DOOR	SINGLE TTY	THRU PASSAGEWAY	FAX MACHINES	COMPOUND TERMINAL (AUTODIN)	OFF-LINE PACKAGE	TEST BAY	RCVR EQUIPMENT BAY
DC PATCHBOARD LINE																				
VF PATCHBOARD LINE	F-F	8																		
	B-B	2																		
ORDERWIRE LINE	F-F	8	8																	
	B-B	2	2																	
TTY PACKAGE EQUIPMENT	F-F	8	8	8																
	B-B	2	2	2																
CRYPTO LINE	F-F	7	7	7	7															
	B-B	2	2	2	2															
FGC-73 CONSOLE	F-F	8	8	8	8	7														
	B-B	2	2	2	2	2														
FGC REMOTE READER	F-F	8	8	8	8	7	8													
	B-B	2	2	1.5	2	2	2													
FGC BRPE	F-F	7	7	7	7	6	7	7												
	B-B	2	2	1.5	2	2	2	0												
TERMINAL EQUIPMENT	F-F	7	7	7	7	6	7	7	6											
	B-B	2	2	2	2	2	2	2	2											
MANUAL PROCESS DESK	F-F	7	7	7	7	6	7	7	6	6										
	B-B	2	2	1.5	2	2	2	0	0	2										
OUTSIDE BULKHEAD	F-F	5	5	5	5	4	5	5	4	4	4									
	B-B	2	2	1.5	2	2	2	0	0	2	0									
THOROUGHFARE DOOR	F-F	5	5	5	5	4	5	5	4	4	4	-								
	B-B	2	2	1.5	2	2	2	0	0	2	0	-								
SINGLE TTY	F-F	7	7	7	7	6	7	7	6	6	6	3	3							
	B-B	2	2	1.5	2	2	2	0	0	2	0	0	0							
THRU PASSAGEWAY	F-F	5	5	5	5	4	5	5	4	4	4	-	-	3						
	B-B	3	3	3	3	3	3	3	3	3	3	3	3	3						
FAX MACHINES	F-F	8	8	8	8	7	8	8	7	7	7	4	4	7	4					
	B-B	2	2	1.5	2	2	2	1.5	1.5	2	1.5	1.5	1.5	1.5	3					
COMPOUND TERMINAL (AUTODIN)	F-F	5	5	5	5	4	5	5	4	4	4	-	-	4	-	-				
	B-B	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3				
OFF-LINE PACKAGE	F-F	8	8	8	8	7	8	8	7	7	7	4	4	7	4	8	4			
	B-B	2	2	1.5	2	2	2	0	0	2	0	0	0	0	3	1.5	3			
TEST BAY	F-F	8	8	8	8	7	8	8	7	7	7	4	4	7	4	8	4	8		
	B-B	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	3	2		
RCVR EQUIPMENT BAY	F-F	9	9	9	9	8	9	9	8	8	8	5	5	8	5	9	5	9	9	
	B-B	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	3	2	2	
TWO SIMILAR EQUIPMENTS F-F		6.4	6.4	6.4	6.4	4.8	6.4	6.4	4.8	4.8	4.8	-	-	4.8	-	6.4		6.4	6.4	8
MINIMUM BACK ACCESS		2	2	1.5	2	2	2	0	0	2	0	-	-	0	-	1.5	3	0	2	2
MINIMUM DISTANCE TO NON-OPERATING OBSTRUCTION		4	4	4	4	3	4	4	3	3	3	-	-	3	-	4	-	4	4	5

Legend:
F-F front to front.
B-B back to back.
Numbers-distance in feet.

To read chart:
Locate first item of interest.
Follow right to arrow.
Down column indicated by arrow to line of second items of interest.
The figure in this block is the minimum separation required.

Example:
Minimum distance between terminal equipment and thoroughfare door —
Between front of equipment and door: four feet.
Between back of equipment and door: two feet.

Figure 3-13. Equipment Access Space Requirement

Table 3-6. Communications Center Siting Separations

FACILITY	SOURCE OF INTERFERENCE	MINIMUM DISTANCE
Communications Center	VLF transmitters	25 mi
	LF, HF transmitters	15 mi
	Transmitters not under Navy control	5 mi*
	Main highways	1000 ft
	Areas capable of industrialization	1 mi
	Radar installation	1500 ft
	Primary HF receiver building and antenna field	2 mi from nearest antenna
	Primary power plant	1500 ft

*Signal from non-Navy station may not exceed 10 millivolts per meter (field intensity) at the location of the building.

CHAPTER 4

THE TRANSMITTER STATION

4.1 GENERAL

Operational requirements determine the number and types of transmitters to be installed at a transmitter station. A small station may have only a few transmitters while a large one, supporting a large communications center, may have more than 100 covering various frequency bands and having power outputs varying from a few watts up to the megawatt range. Transmitters for the HF, MF, LF and VLF bands may all be located at the same transmitter station, but the discussion in this chapter is generally confined to HF transmitter systems which range from 1 kW to 200 kW peak envelope power (PEP) output. The high-power systems associated with MF, LF and VLF transmitters will be discussed in other handbooks to be published later and, therefore, are not addressed directly here.

The transmitter station is sited on reasonably flat or rolling terrain in accordance with the factors discussed in NAVELEX 0101, 103 — "HF Radio Propagation and Facility Site Selection." The transmitter building, located in the center of the antenna field (see figure 4-1), is designed to satisfy the operational requirements and to promote operational efficiency. At small stations the transmitters are located in a transmitter room and a control and monitoring facility is installed in an area central to the transmitters. The width of a typical transmitter room is 26 feet, which permits placement of two rows of transmitters facing front to front with an 8-foot-wide center aisle and with approximately 4 feet of space behind the transmitters. Large stations have transmitter buildings with 26-foot-wide wings arranged in the form of a "T," a cruciform, or a star with the control and monitor area placed at the junction of these wings. This concept is illustrated by figure 4-2. Associated systems and facilities such as microwave equipment for the intersite link, terminal equipment, an electronic repair shop, spare parts storage, and office space are located in separate rooms.

Information for transmission is received from the communications center via intersite links. The need for survivability and reliability may require the provision of alternate links routed over separate paths between the communications center and the transmitter site. Chapter 6 gives the intersite link requirements and general criteria for the type of link to be employed. The routing of each circuit within the station will be in accordance with the standard plans discussed in chapter 2.

4.2 HF TRANSMITTING EQUIPMENT

NAVELEX supplies general purpose independent sideband (ISB) transmitters as part of the planning to achieve operational flexibility. Present generation transmitters are capable of the classes of emission shown in table 4-1; they are designed for matched loading into 50-ohm coaxial transmission lines; and they may be tuned and placed into operation by operators at the equipment or by remote control from circuit operator positions. Spare transmitters and associated equipment are provided for maintenance and backup on a basis of one spare for every five active units.

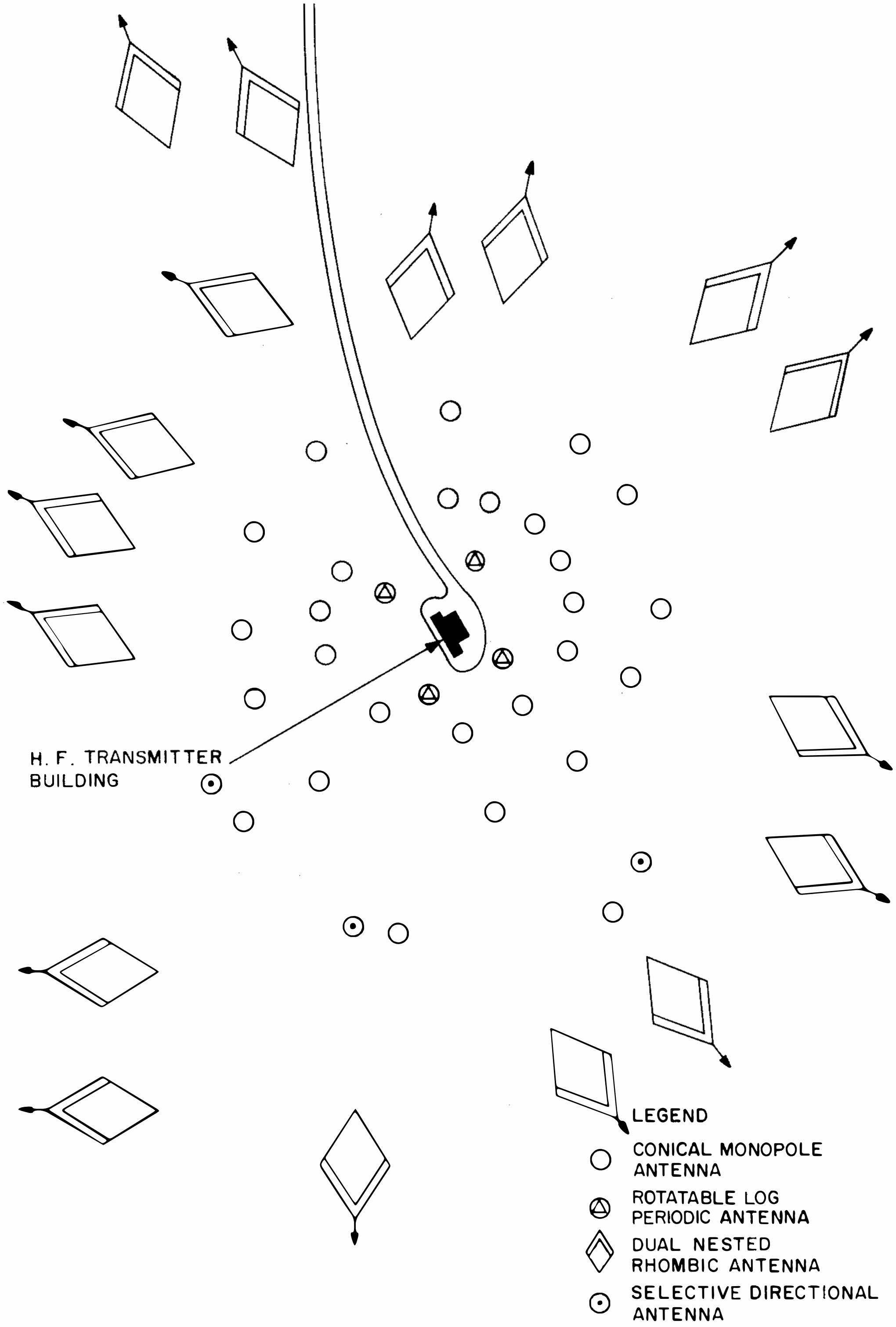


Figure 4-1. Transmitter Building Location

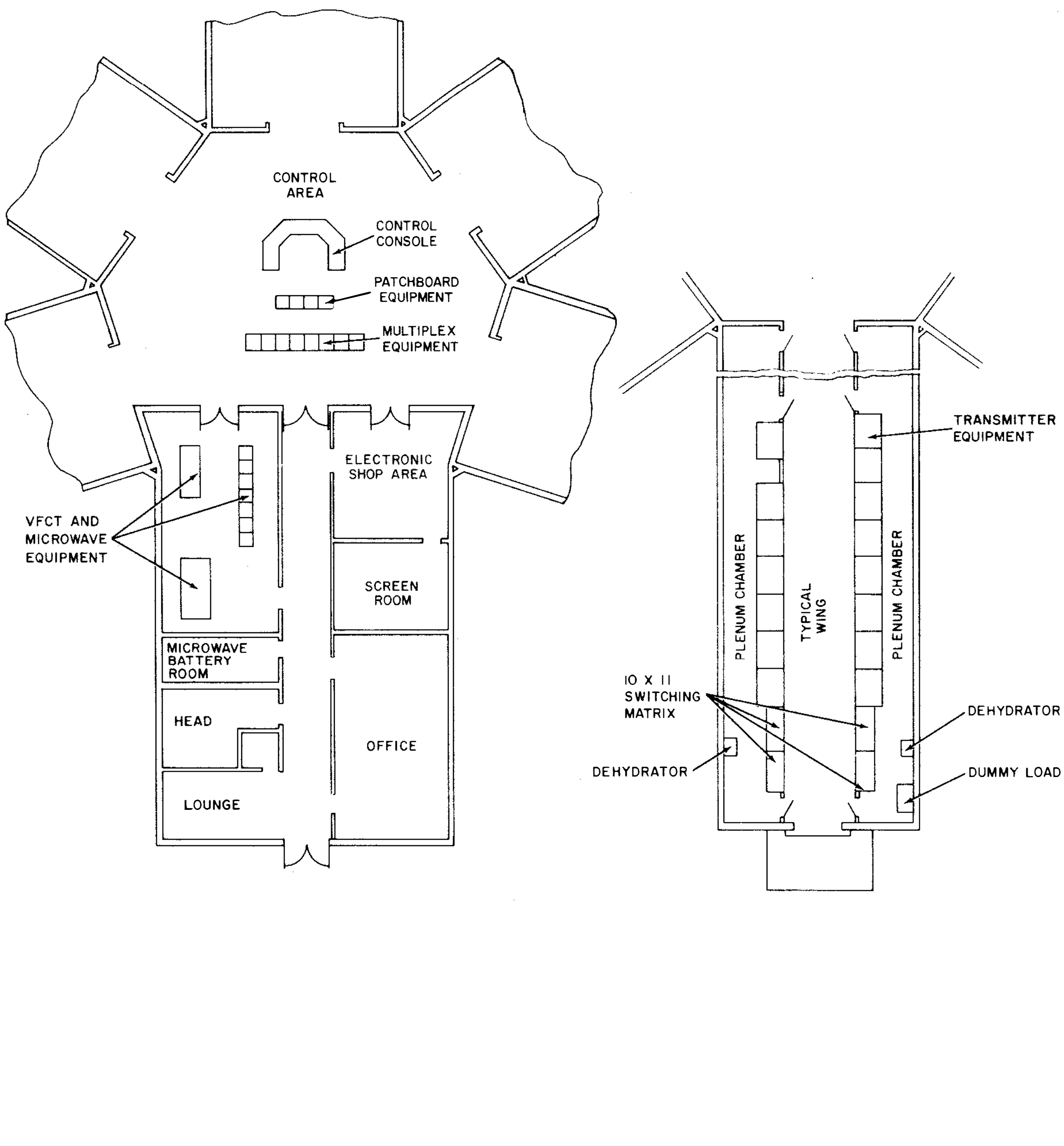


Figure 4-2. Large Transmitter Building and Plenum Concept

TABLE 4-1. EMISSION DESIGNATION

Designation	Description
0.1A1	Continuous wave, on-off keying telegraphy, 100-Hz bandwidth (CW Telegraph at 25 WPM)
1.7A7J	Amplitude modulated, multichannel, voice-frequency telegraphy, suppressed carrier, single sideband, 1700-Hz bandwidth (100 WPM, 8 channel)
3A3J	Amplitude modulated, telephony, suppressed carrier, single sideband, 3000-Hz bandwidth
3A7J	Amplitude modulated, multichannel voice-frequency telegraphy, suppressed carrier, single sideband, 3000-Hz bandwidth
3A9A	Amplitude modulated, combination telegraphy and telephony, reduced carrier, single sideband, 3000-Hz bandwidth
3A9J	Amplitude modulated, combination telegraphy and telephony, suppressed carrier, single sideband, 3000-Hz bandwidth. A single sideband, suppressed carrier, amplitude modulated emission occupying 3 kHz of spectrum and which does not fall into any of the preceding categories. Examples of emissions properly classified as 3A9J include data, simultaneous voice and tone telegraphy, simultaneous voice and data, or simultaneous data and telegraphy.
6A3	Amplitude modulated, telephony, double sideband full carrier, 6000-Hz bandwidth
6A3B	Two independent 3-kHz intelligence channels authorized for voice transmission. The suppressed carrier frequency is the same as the assigned frequency.
6A7B	Two independent 3-kHz intelligence channels for multichannel telegraphy transmission. The suppressed carrier frequency is the same as the assigned frequency.
6A9B*	Amplitude modulated, combination telegraphy and telephony, two independent sidebands, 6000-Hz bandwidth
9A3B, 9A7B 9A9B*	Amplitude modulated, combination telegraphy and telephony, three independent sidebands, 9000-Hz bandwidth
12A3B, 12A7B 12A9B*	Four independent 3-kHz intelligence channels for voice, multichannel telegraphy, or composite transmissions respectively. Suppressed carrier frequency is the same as the assigned frequency.
1.24F1	Frequency modulated, one of any two frequencies being emitted at any one instant, 1240-Hz bandwidth (100 WPM RATT)
4F4	Frequency modulated, facsimile transmission, 4000-Hz bandwidth

*Note that for 6A9B, 9A9B or 12A9B emissions, one 3-kHz intelligence channel may carry only voice and another only telegraphy and still fall within the definition of composite transmission.

Transmitters are rated by their output power and are classified in accordance with the designations listed in table 4-2. General purpose ISB transmitters provided by NAVELEX are rated at either 1 kW, 10 kW, 40 kW or 200 kW PEP output.

4.3 TRANSMITTER CONTROL

A centralized area for control, monitoring and testing of transmitting systems is provided at each transmitter building on the station. This center includes provisions for all elements of transmitter control other than the switching of RF output and the initial turn-on of the transmitters. To facilitate operations, the following equipments may be incorporated in this area:

a. Patchboards for each transmitter DC or tone-key input and each sideband channel input.

b. Transmitter status indicators.

c. A display to show transmitter circuit employment and antenna assignment.

d. Controls for steerable antennas.

e. Teletype and voice communications equipment used to coordinate with the communications center.

f. Controls for remote transmitter tuning.

g. Circuit monitoring and test equipment such as frequency counters, oscilloscopes, spectrum analyzers, signal generators, and level measuring devices.

h. RF input and power output quality and level-indicating equipments.

i. A station frequency standard to ensure the accuracy and stability of transmitter frequency synthesizers.

Table 4-2. Standard Transmitter Power Designations

POWER	DESIGNATION	POWER RATING PEP
Low	LP	Under 1 kW
Medium	MP	1-5 kW
Medium High	MHP	5-20 kW
High	HP	20-50 kW
Very High	VHP	Above 50 kW

4.4 CHANNELIZATION AND ROUTING

Signal flow with a minimum of processing is preferred. It is desirable to transmit 3-kHz bandwidth audio signals in the same form as received from the communications center. When the signal at the output of the link demultiplexing equipment is routed directly to the transmitter, the resultant transmission is more likely to be error free and reliable. In order to approach this objective, the following design criteria are established for the links and for the information received:

a. All links to the transmitter site carry information on 4000-Hz nominal bandwidth link channels.

b. The information for each destination is received on a dedicated link channel (3-kHz bandwidth audio channel) or a voice frequency carrier telegraph (VFCT) channel which may be part of a 3-kHz bandwidth audio channel.

c. All signals received via the links are routed via patchboards to provide the flexibility to use any signal to modulate (or key) any transmitter.

Information that is to be transmitted by on-off keying (CW emission) or frequency shift keying (FSK emission) is received in the form of VFCT tones. The station VFCT terminal separates the tones into channels and converts the tones into DC keying signals that are routed through patchboards to the appropriate transmitter keyer or keyers.

Information for use within the station such as orderwire traffic and DC control signals is received in the form of VFCT tones via the intersite links. The station VFCT terminal separates these tones into channels and converts the tones into DC signals that are in turn routed via distribution frames and patchboards to teletype equipment or to the applicable transmitter. In-band control signals are also received at the transmitter station. In-band signaling incorporates control information with the information to be transmitted. Separation of the in-band control signals from the information to be transmitted is accomplished at the transmitter. Therefore, a straight-through type of transmission is possible because separate distribution of the control signal is not required.

All in-house signal and control information (both audio and DC) is distributed by shielded-pair cabling. In general, the in-house circuit flow is from the link terminal equipment to a distribution frame, to a patchboard, back to a distribution frame, and then to the transmitter, orderwire terminal or other electronic equipment. The link channels between the communications center and the station are terminated on the transmitter station main distribution frame (MDF) and then routed to an intermediate distribution frame (IDF). The MDF and the IDF may be combined as long as distinctly separate areas are maintained within the frame.

4.5 SYSTEM FLEXIBILITY

4.5.1 Audio and DC Signal Flexibility

Maximum operational flexbility is achieved by installing circuit patchboards and distribution frames. The patchboards provide access for equipment maintenance, for signal monitoring and for rerouting of signals as required by operations in the event of an equipment failure. All circuit patchboards are wired "normal through" so that no patch cord connections are required when the system is operating as planned. Wiring criteria concerning frames and patchboards are discussed in chapter 9.

4.5.2 RF Signal Flexibility

RF switches provide signal flexibility by permitting transmitters to operate into selected antennas or into a dummy load to satisfy various frequency, directivity and maintenance requirements. Crossbar switching matrices are the latest approved switching devices. One of these matrices is shown in figure 4-3. The following criteria govern transmitter RF output switching:

a. One transmitter may feed only one antenna at a time.

b. Antennas connected to an RF switching matrix must be capable of handling the maximum output power of any transmitter terminated on the matrix.

c. Multicoupler inputs should appear on the antenna switching matrix.

d. Multicoupler outputs may appear on the antenna switching matrix if this degree of flexibility is economically justifiable.

e. When more than one matrix is installed, two input trunks and two output trunks are required between matrices to increase flexibility.

f. Each matrix should provide one output to a dummy load to permit transmitter tuning and testing without radiating radio signals.

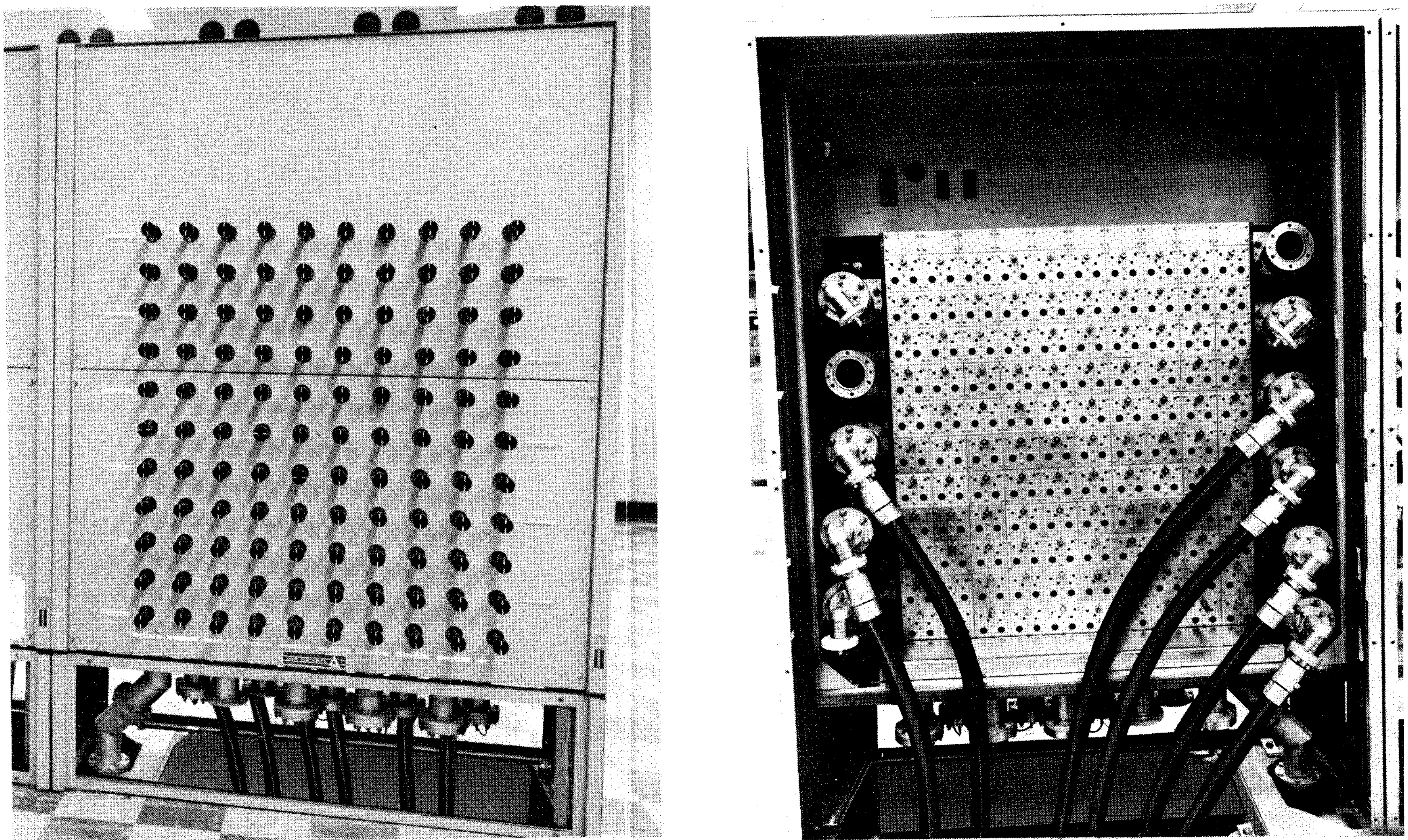
g. Electrical interlocks must prevent activating a transmitter that is not properly connected to an antenna or a dummy load, and must prevent disconnecting an active transmitter from the antenna or dummy load.

h. Transmitter RF switching matrices are designed for use with 50-ohm coaxial transmission lines.

i. Transmitter RF switching matrices should be located near the transmitters, but they should not be part of the transmitter control facility.

4.6 CONSTRUCTION AND INSTALLATION

Transmitter buildings are usually permanent structures; however, present DOD instructions state that new communications facilities in overseas areas on foreign soil are to be transportable. These transportable stations are discussed in chapter 13. When new, permanent construction is required, the building is designed and constructed by the Naval Facilities Engineering Command (NAVFAC) to include the specific requirements of the electronic installation as stated in the BESEP. In addition to the general building requirements for communication stations, discussed in chapter 7, the following criteria apply specifically to the transmitter building.



FRONT

BACK

Figure 4-3. Transmitter Antenna Crossbar Switching Matrix

4.6.1 Building Features

a. The transmitter room (wings) and rooms for other electronic equipment will be windowless and free from obstructions and columns.

b. A central area is required for transmitter control, monitoring and testing. Preferably, this area should be chosen so that operators will be able to see all the transmitters.

c. The floor will be concrete and will be designed to support a loading of 200 pounds per square foot.

d. A truck loading platform is required at the end of each transmitter wing. Door access must be sufficient for the largest equipment or equipment subsection.

e. An electronic maintenance shop is required. This shop will contain a shielded room that provides 60 dB attenuation of electromagnetic radiation from 100 kHz to 100 MHz.

f. Cable vaults are normally installed to serve as the entrance for all RF and signal cables.

g. The building must include features that tend to isolate transmitter acoustic noise from the operating and control areas.

4.6.2 Building Environment

The need for equipment ventilating air and the requirements for cooling the building are based upon the climatic conditions and the heat generated within the building by personnel, lighting and equipment. The BESEP must specify the electronic equipment heat losses (unit and total) and the air flow (CFM) requirement (unit and total) for the electronic equipment. NAVFAC designs and installs the necessary environmental systems taking into account the electronic equipment heat losses and air flow requirements that are stated in the BESEP.

The preferred method of cooling transmitters is one using ventilating air. Heat is transferred directly to the air by passing the ventilating air directly over the parts to be cooled or indirectly by passing the air through heat exchangers that are integral parts of the transmitters.

Except for new-generation equipment, for which acceptable intake and exhaust static pressures have been specified, ducting of air to and from the transmitter is not recommended, since varying head pressures may be created. As a general rule, the transmitter itself must control the flow of ventilating air. The preferred method of supplying ventilating air to a transmitter is through the use of a plenum concept such as that illustrated by figure 4-4. With this method no head pressures are developed since air can flow freely through the transmitters even when the building supply and exhaust systems are secured.

As a side benefit, the plenum concept provides a degree of sound isolation by isolating transmitter blower and rushing air noises from the operating area. Moreover, it makes possible separate air conditioning for the portions of the building occupied by personnel.

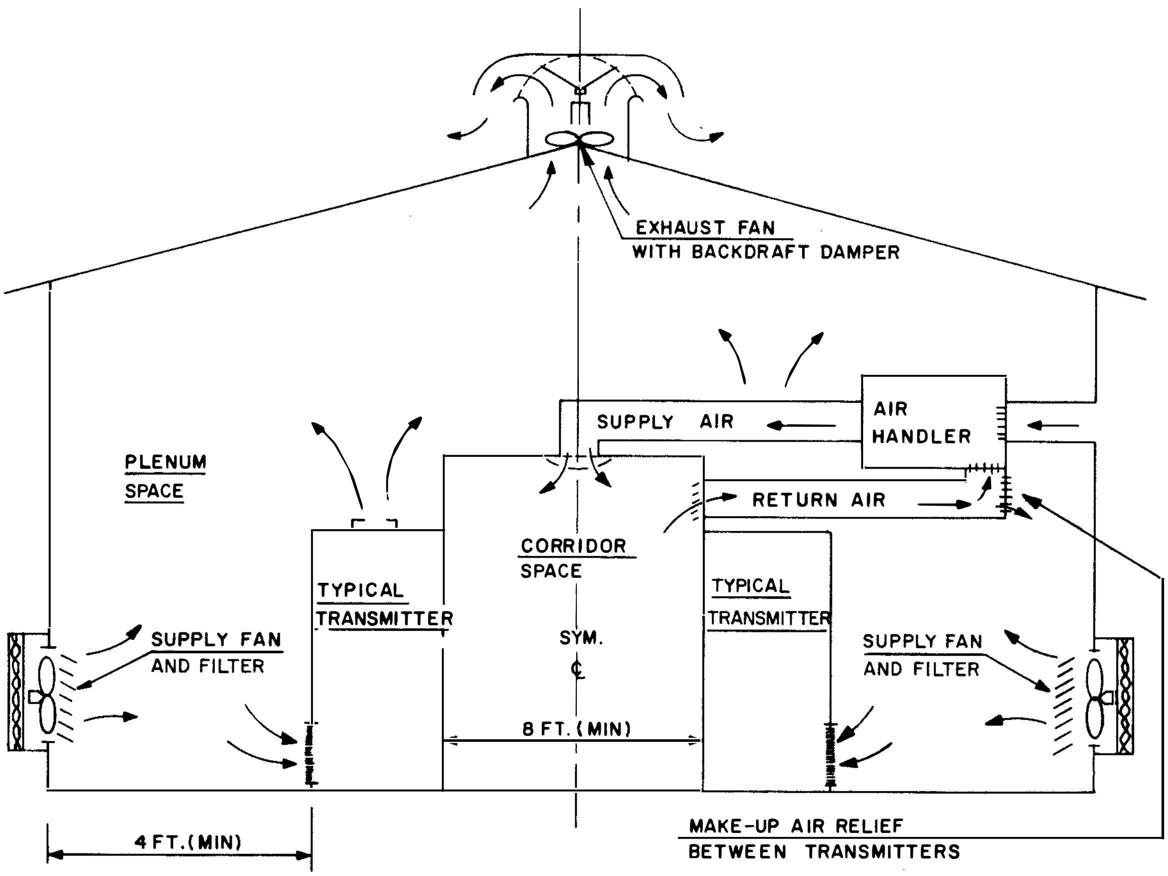


Figure 4-4. Plenum Concept

4.6.3 Building Grounding and Bonding

At this writing, studies are being planned which will result in establishing new criteria for the grounding and bonding of the transmitter building. At completion of the studies, these new criteria will be incorporated into this handbook. Meanwhile, NAVFAC DM-23--"Communications, Navigational Aids, and Airfield Lighting" should be used as the source of criteria for bonding and grounding of transmitter buildings.

4.6.4 Building Electrical Power

The electrical power requirements for electronic equipment are specified in the BESEP for use by NAVFAC or the NAVFAC Engineering Field Division (EFD) in designing the station electrical power system. The demand load for the transmitter building electronic equipment is 100% of the connected technical load. For new facilities the primary power should include design for 25% growth of the total electrical load. The primary power source for a transmitter facility is usually a commercial power company unless the commercial power is inadequate, in which case a class A power plant is installed. Factors that determine the adequacy of a commercial power company are contained in DM-4 — "Electrical Engineering." The following criteria are applicable to the transmitter building power system:

a. New facilities are to be designed around a 480-volt, 3-phase, either 50- or 60-Hertz system and are to have separate buses for the technical and nontechnical loads.

b. At new facilities, transmitters will require power as follows:

(1) Power amplifier: 480-volt, 3-phase, 3-wire from the technical bus.

(2) Exciter: 120-volt, single-phase from the technical bus.

(3) Transmitter utility outlets: 120-volt, single-phase from the nontechnical bus.

c. New transmitter equipment is adaptable for use at existing facilities which have 208, 230, or 240 volt systems; therefore the existing power distribution system normally is used when new equipment is installed. Changing to a 480-volt distribution system will be authorized in connection with making building additions or increasing power capacity only if economically justifiable.

d. For personnel safety, positive disconnect switches operable from the rear of the transmitters must be installed in the line supplying each transmitter power amplifier. The equipment circuit breaker that is operable only from the front of the transmitter is not sufficient for this safety disconnect. When plenum chambers are used this safety disconnect must be inside the plenum near the back of the transmitter.

e. A separate circuit breaker for the exciter of each transmitter must be installed at the technical power panel.

f. Class D, no-break power is not provided for a transmitter building.

g. The need for emergency power is considered on a case-by-case basis. When such power is included, it will be tailored to meet the selected communications requirements upon which the need is based.

4.6.5 Building Siting

The transmitter building is located in the center of the antenna park to minimize the length of the antenna trnasmission lines. The following planning distances have been established for separating the transmitter station from other facilities.

a. Overhead high-tension power lines, 1000 feet from the nearest antenna.

b. Main highways, 1000 feet.

c. Other transmitter stations, 3 miles.

d. Airfields and glide paths, 3 miles when the station is used for general purpose communications.

e. Airfields and glide paths, 1500 feet when the station is used in conjunction with air operations.

f. Receiver buildings and associated antenna fields, 25 miles when VLF transmitters are installed.

g. Receiver buildings and associated antenna fields, 15 miles when LF and HF transmitters are installed.

CHAPTER 5

THE RECEIVER STATION

5.1 GENERAL

The receiver station is equipped with all the facilities needed to receive propagated RF energy and to convert it into signals that comprise the receive circuits from distant locations. The basic elements of the station are the antenna field and the building housing the electronic equipment. The antennas intercept the RF energy from the propagating medium and the electronic equipment converts this RF energy into communications signals that are then relayed to the communications center for direct use or for retransmission to other users. The receiving equipment is installed to satisfy the station's requirements for specific number and types of circuits. Some redundancy in equipment installation is provided to facilitate maintenance and this may allow for a small expansion of capability. Table 5-1 lists typical equipment that may be found at a receiver station. However, the particular equipments required at the receiver station to implement a specific circuit are shown by the applicable NAVELEX standard plan (chapter 2).

Reception of desired radio signals is the controlling factor when a radio receiver station is designed and constructed. Any other consideration, such as the need for survivability against bomb damage or a natural disaster, must not be permitted to degrade the ability of the station to function as a radio receiving station. The principal factors entering into the general arrangement and construction of the station are:

a. Fundamental suitability for conducting efficient communications.

b. Adaptability to meet normal expansion requirements and emergencies.

c. Total cost.

The above factors can be assessed by: first, determining the reception capabilities to be provided; second, evaluating the construction and arrangement against certain minimum necessary conditions that must be satisfied in order to permit the desired reception and third, weighing the relative advantages of each factor with respect to the required minimum specified. One of the methods of integrating the above factors into the design is to provide for maximum flexibility in the use of antennas and receivers. An accepted method for accomplishing this is to include (1) multicouplers to supply multiple outputs from a single antenna, (2) RF switches and patchboards to feed any receiver with any RF input, and (3) audio and DC circuit patchboards to distribute the receiver and ancillary equipment outputs. The station designer must also carefully evaluate each requirement against the corollary objective of eliminating or reducing the need for circuit and equipment operators.

Table 5-1. Typical Receiver Station Equipment

FREQ (MHz)	RCVR TYPE	EMISSION TYPE	SENSI-TIVITY µV	ANT. Z	OUTPUT Z	POWER REQUIREMENTS				DIMENSIONS			VOL		MANU-FACTURER	ADDITIONAL DATA AND REMARKS
						WATTS	VOLTS	PHASE	FREQ (Hz)	HT IN.	WIDTH IN.	DEPTH IN.	CU FT	WT LBS		
.014-.030	AN/BRR-3	A1, A2, F1			600-200		115	1	60							CV-57/URR or CV-60/ URR Converter
.014-.6	AN/FRR-21	A1, A2, F1	3.5-8	73 Bal 200 Bal	600	87	105, 115, 125	1	50, 60, 400	9	19	18	2	75	RCA	Identical to AN/SRR-11 Cabinet mounted version
.014-.6	AN/SRR-11	A1, A2, F1	3.5-8	73 Bal 200 Bal	600	87	105, 115, 125	1	50, 60, 400	9	19	18	2	75	RCA	Table version of AN/FRR-21
.015-1.5	R-389/URR	A1, A2, A3, F1	6	125 Bal	600	225	115, 230	1	48-62	11	19	17	2.5	85	Collins	Tuned manually or motor tuning
.014-.6	AN/WRR-6	A1, A2, F1	0.5-4.0	50 200 µµF	600 (2)	60	105, 115, 125	1	50, 60, 400	9	17	17	1.5	70	Magnavox	
.05-.4-.5 2-32	R-5007/ FRR-502	A1, A2, A3, F1	1	73 Bal 300	600	85	110, 220	1	50, 60	6	19	15	0.9	35	TMC	Band changes by plug-in units
.02-32	AN/FRR-49	A1, A2, A3, F1	10	50	600	85	110, 220	1	50, 60						TMC	
.03-.3	SRR-19	A1, A2, A3, A3A, A3B, F1	1-2	50 Unbal	600	200	105, 115, 125	1	50, 60, 400	12-1/4	17-1/4	22-1/2	2.75	125	National Co., Inc.	
.010-.6	R-1609/FRR*														General Instruments	
.25-8	AN/FRR-22	A1, A2, A3, F1	3	73 200	600	87	105, 115, 125	1	50, 60, 400	9	19	18	2.2	75	RCA	Rack mounted AN/SRR-12
.25-8	AN/SRR-12	A1, A2, A3, F1	3	73 200	600	87	105, 115, 125	1	50, 60, 400	9	19	18	2.2	75	RCA	Table version of AN/FRR-22
.5-54	AN/FRR-28	A1, A2, A3, F1, F4	2.3	73	600 8000	570	115, 230	1	50, 60,	88	24	23	56	344	Press Wireless	2 Type SP-600-JX6 rcvrs for diversity operation
.5-32	AN/FRR-38	A1, A2, A3, F1	1	50 Bal 125 Bal	600	270	115, 230	1	48-62	76	21	21	18	490	Hoffman	2 Type R-390/URR rcvrs, with CV-116/ URR converter for diversity terminal
.5-32	R-390/URR	A1, A2, A3	1-3	50 Bal 125	600	270	115, 230	1	48-62	11	19	17	2.4	70	Collins and Others	R-390A/URR has same characteristics
.5-4	RBB	A1, A2, A3	6	73 1500 (1) Wire	600	100	110-120	1	55-65	15	19	21	3	82	RCA	Power supplied separately and can supply two rcvrs

Table 5-1. Typical Receiver Station Equipment (Continued)

FREQ (MHz)	RCVR TYPE	EMISSION TYPE	SENSITIVITY μV	ANT. Z	OUTPUT Z	POWER REQUIREMENTS				DIMENSIONS			VOL		MANUFACTURER	ADDITIONAL DATA AND REMARKS
						WATTS	VOLTS	PHASE	FREQ (Hz)	HT IN.	WIDTH IN.	DEPTH IN.	CU FT	WT LBS		
.54-54	R-274/FRR	A1, A2, A3, F1	2.3	50 Bal 200	600	130	95-260	1	50, 60	11	19	18	2	58	Hammarlund	SP-600-JX6
.54-30.5	R-388/URR	A1, A2, A3	5	125 Bal Hi Z	4/600 IF 50	85	115, 230	1	47-75	11	19	13	2	43	Collins	51-J-4
.54-31	R-840/URR	A1, A2, A3, A4	1	75 Bal 200 Bal	4/8/16/ 600	90	115, 230	1	50, 60	11	19	14	2		TMC	
2-30	R-1051/URR R-1051B/ URR	A1, A3A, A3B, A9, F1, F4	A9-2 A3-4	50	600 and 600	55	115	1	48-450	7	17.38	18.9	1.33	70	General Dynamics and Bendix	Separate shock mount MT-3114/UR
2-32	AN/WRR-2 AN/FRR-59	A1, A2, A3, A9, F1, F4	A1-1.5 A2-3.0 A3-6.0 A9-4.0	50	600 and 600	250	105, 125	1	50, 60	25.8	22	24	8.6	250	National Co. and Arvin Ind.	Separate mounting MT-2293/WRR-2
2-32	AN/FRR-19	A1, A2, A3, F1	4-5	73 200	600	87	105, 115, 125	1	50, 60, 400	9	19	18	2.2	75	RCA	AN/FRR-23 with CV-57/URR or CV-60/URR converter
2-32	AN/FRR-23	A1, A2, A3, F1	4-5	73 200	600	87	105, 115 125	1	50, 60, 400	9	19	18	2.2	75	RCA	Rack mounted model of AN/SRR-13
2-32	AN/SRR-13	A1, A2, A3, F1	6-10	73	600	87	105, 125	1	50, 60 400	9	19	18	2.3	75	RCA	Table mounted FRR-23
2-30	AN/GRR-17	A1, A2, A3, F1, A3J	0.6-2.5	50	600	24 50	24 FCD 115 VAC	- 1	DC 50, 60, 400	7 9	17 19	10 13	0.7 1.3	33 40.5	National Co., Inc.	Rack mounted or transit case
2-32	AN/FRR-60 (V) 2	A1, A2, A3, F1, A4, A3J, A9B	1.0	50	600 (8)		115, 230	1	48-62	69	47	30	58	660	TMC	DDR - 5A Model
2-32	AN/FRR-60 (V) 3	Same	1.0	50	600 (4)	1000	115, 230	1	48-62	69	25	30	30	637	TMC	DDR - 5B Model
2-32	AN/FRR-60 (V) 5	Same	1.0	50	600 (8)	2000	115, 230	1	48-62	69	47	30	58	1162	TMC	DDR-5L Model
2-32	AN/FRR-60 (V) 6	A1, A2, A3, F1, A4, A3J, A9B	1.0	50	600	1000	115, 230	1	48-62	83	25	30	36	878	TMC	DDR-R-5BR Model
2-32	AN/FRR-60 (V) 7	Same	1.0	50	600	1500	115, 230	1	48-62	69	47	30	58	660	TMC	DDR-RR-5M Model

Table 5-1. Typical Receiver Station Equipment (Continued)

FREQ (MHz)	RCVR TYPE	EMISSION TYPE	SENSI-TIVITY µV	ANT. Z	OUTPUT Z	POWER REQUIREMENTS WATTS	VOLTS	PHASE	FREQ (Hz)	DIMENSIONS HT IN.	WIDTH IN.	DEPTH IN.	VOL CU FT	WT LBS	MANU-FACTURER	ADDITIONAL DATA AND REMARKS
2-32	AN/FRR-60 (V) 8	Same	1.0	50	600	1500	115, 230	1	48-62	69	47	30	58	660	TMC	DDR-R-5M Model
2-32	AN/FRR-60 (V) 11	Same	1.0	50	600	1500	115, 230	1	48-62	83	25	30	36	878	TMC	DDR-5BR1 Model
2-32	AN/URR-63 (V) 1*														TMC	
2-32	AN/URR-63 (V) 2*														TMC	
2-32	AN/URR-64 (V) 1*														TMC	
2-32	AN/URR-64 (V) 2*														TMC	
2-32	AN/URR-64 (V) 3														TMC	
2-32	AN/FRR-72	A1, A2, A3, A4, A3J, A9J, F1	1.0	50	600	1070	115, 230	1	48-62	83	25	30	58	880	TMC	DDR-5B Model
225-400	AN/URR-13	A2, A3	8	50	600	125	115	1	50, 60	9	19	18	1.5	57	Federal Telephone	Single channel
225-400	AN/URR-28	A2, A3	8	50	600	197	115	1	50, 60	9	19	23	3	62	National Co., Inc.	10 Preselected Xtal controlled channels
225-400	AN/URR-35	A2, A3	8	50	600 50 Video	98	115	1	50, 60	9	19	18	1.5	57	Federal Telephone	Preset or manual controlled channels

* Under Tactical and Operational Testing

5.2 HF RECEIVERS

HF receivers capable of processing the various types of emissions in table 4-1 are preferred. Use of multipurpose receivers provides operational flexibility and allows equipment substitution for maintenance and for equipment failure. However, the need for flexibility must not be allowed to overshadow other considerations such as:

a. The cost of special purpose versus general purpose equipment.

b. The availability of equipment for use on other circuits.

c. The percentage of time that an equipment would be needed for special purpose use.

d. The requirements for additional units during maintenance periods or for replacement of a failed unit.

e. The availability of the equipment by the time the installation is required for operations.

For proper facility planning, it is important that the designer have a thorough knowledge of all such factors.

HF receivers in use at shore stations vary from those that receive only a single channel 3-kHz sideband to those that receive and independent sideband (ISB) modulated RF carrier consisting of an upper and a lower sideband, each 6 kHz wide. Usually receivers are controlled manually at the front of the unit, but some later model receivers, and those undergoing development, may be controlled remotely from a distant operator position. Remote control from the distant operator position is usually accomplished by sending teletype or digital instructions to a receiver control unit which automatically makes the proper adjustment. The ISB receiver itself may demultiplex each of the 6-kHz sidebands into two 3-kHz audio channels. Receivers that include all necessary demultiplexing and converting equipment are preferred over those with separate demultiplexers. HF receivers capable of receiving single-channel frequency shift keying (FSK) or on-off keying (CW) signals are also required at various receiver stations. The outputs of these receivers are converted into audio tones for further distribution and processing. Here again, the preferred receivers are those that perform this conversion as an integral function without the use of auxiliary devices.

5.3 SIGNAL PROCESSING AND DISTRIBUTION

A minimum of signal processing is accomplished at the receiver building. Most 3-kHz circuits are relayed to the communications center where the signal is processed to extract the intelligence. Information received on CW circuits is relayed via teletype to the communications center for distribution or retransmission; however, the CW circuit is usually operated from within the receiver building. From the operational standpoint, the converter/comparator equipment associated with diversity reception of single-channel FSK performs best when located in the receiver building. The resulting DC signal is routed to a processing room in the receiver building or is relayed over the intersite communications link via a VFCT system to the communications center for processing. Experience has shown that better operation of the Ship/Shore

Itinerant Orestes circuit is obtained when all processing is accomplished within the receiver building. Therefore, a receiver building usually contains a ship/shore room for signal processing.

Signals are distributed within the receiver building in accordance with the NAVELEX standard plan for the particular circuit being implemented. The NAVELEX standard plan for the circuit specifies whether the information is to be processed within the receiver building or relayed to the communications center for processing. The location selected for processing is the one that has been found to be the most operationally and technically efficient.

5.4 CHANNELIZATION AND ROUTING

All receiver radio outputs, except those in the ship/shore room are routed to the receiver control area. There, they are monitored for proper level adjustment and quality before transmission to the communications center or processing in the ship/shore room. Each receiver output is distributed through shielded, twisted-pair cabling to distribution frames and patchboards. The main distribution frame and intermediate distribution frame(s) may be combined. The wiring criteria for such distribution are described in chapter 9. When an intersite communications link between the receiver building and the communications center is required, the main distribution frame is the place of interface. All information to be passed over this intersite link, which may be a telephone cable system as well as a microwave system, must be in an audio form capable of being passed over a 4-kHz bandwidth circuit. Some telephone cable and all microwave intersite link systems cannot directly pass DC signals. The DC signals are converted by VFCT prior to transmission over the intersite link. DC signaling may be permitted where the intersite cable link characteristics allow such operation.

5.5 RECEIVER PATCHBOARDS

The outputs of receivers are terminated at audio patchboards in the receiver control area. These outputs are arranged in a logical sequence usually starting from the upper left-hand portion of the board. ISB receiver outputs are labeled as to sideband and channel in accordance with table 5-2 and the outputs on the patchboard are arranged as shown in figure 5-1, or 5-2. The arrangement shown in figure 5-1 is for use with an up-to-date receiver; that shown in figure 5-2 is for use with systems that employ separate demultiplexers. When receivers have separate outputs for FSK or CW signals these outputs are terminated on the audio patchboard. All FSK outputs are grouped together and arranged in numerical order according to the receiver number. Separate outputs for CW signals are terminated and arranged in a similar manner.

5.6 RF DISTRIBUTION

Present day antennas, receivers and intermediate equipments are designed for RF 50-ohm impedance matching. Therefore, when new systems are being planned, all RF signal distribution is to be accomplished using 50-ohm coaxial cables. Many existing receiver sites have 70- and 75-ohm coaxial cables serving as the RF distribution system. The 70- and 75-ohm systems are not to be updated with 50-ohm cables, except on an individual basis as may be required because of deterioration or other communications considerations. Updating to 50-ohm coaxial cables may also be authorized when major installations at the site would make replacement economically

Table 5-2. Receiver Output Nomenclature

DESIGNATION	SIDEBAND OR SIDEBAND PART
A_1/A_2	6-kHz Upper Sideband
B_1/B_2	6-kHz Lower Sideband
A_1	3-kHz Inner Portion, Upper Sideband
A_2	3-kHz Outer Portion, Upper Sideband
B_1	3-kHz Inner Portion, Lower Sideband
B_2	3-kHz Outer Portion, Lower Sideband

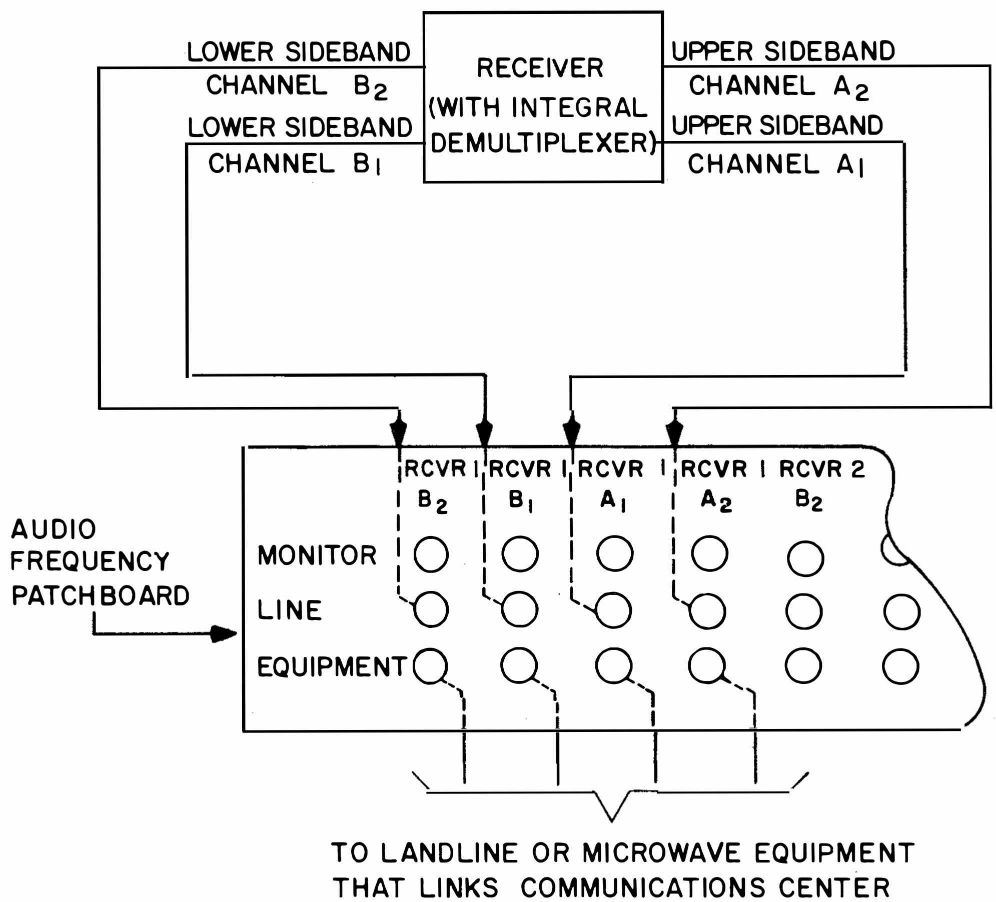


Figure 5-1. Receiver Patchboard (Integral Demultiplexer)

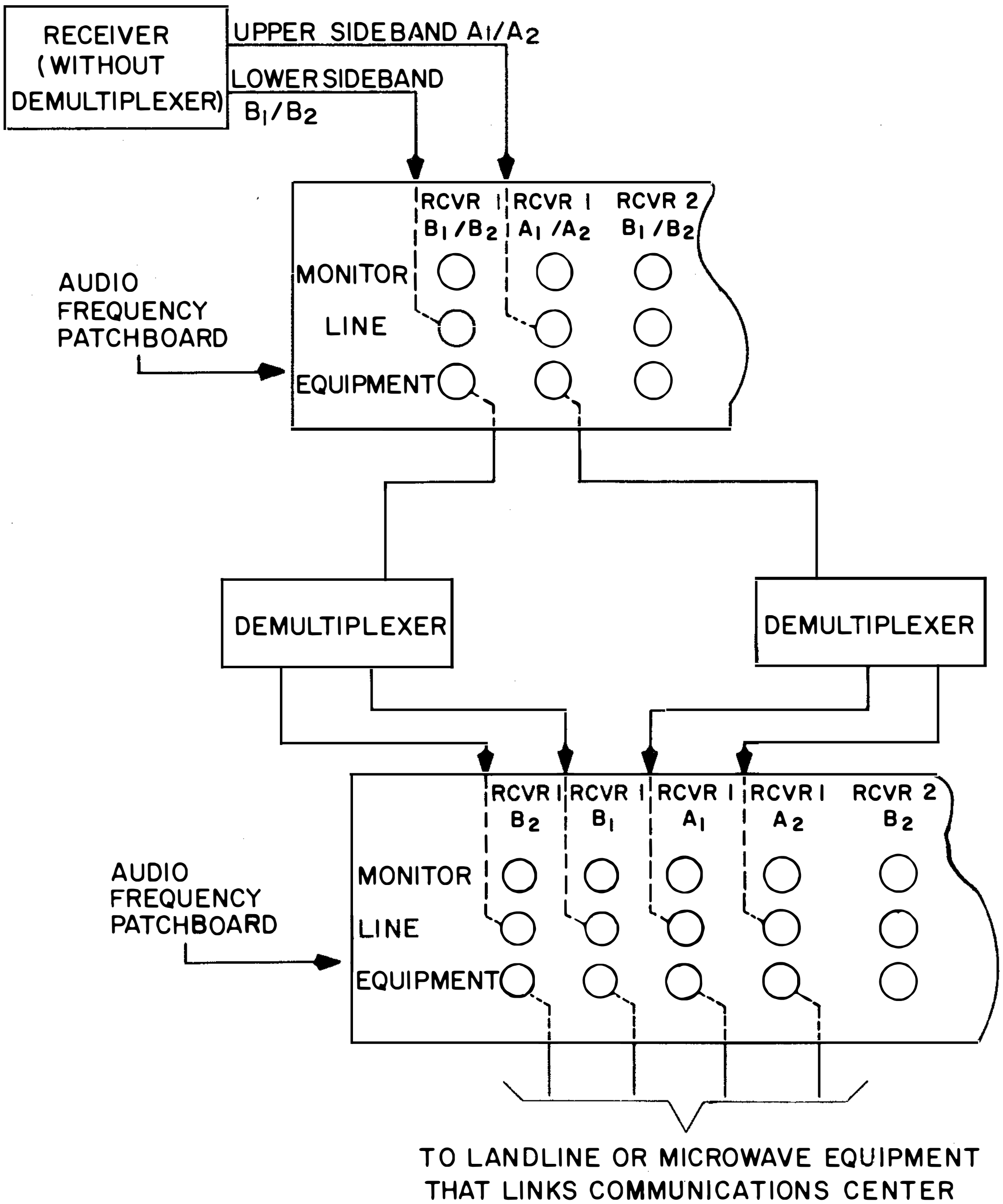


Figure 5-2. Receiver Patchboard (Separate Demultiplexer)

feasible. When new items of equipment are installed at sites using 70- or 75-ohm cabling systems, the impedance mismatch is usually acceptable.

Switching matrices, or patchboards, such as the one shown in figure 5-3, provide for flexibility in the RF distribution system by terminating:

a. Each antenna output.

b. Each multicoupler input and output.

c. Each receiver RF input.

These switching matrices, or patchboards, are used by operators to test, substitute and bypass equipment.

5.6.1 Antenna Multicouplers

Receiver multicouplers permit the use of a single antenna as the signal source for more than one receiver by providing several outputs identical to the input. Although passive multicouplers are used occasionally, most multicouplers are active devices with amplification limited to that which is necessary to raise the output of each channel to the level of the input. Multicouplers can be cascaded to provide additional multiple outputs.

It is an accepted practice to install multicouplers in a cascaded "normal-through" arrangement when operations require more than 8 outputs of a single antenna. Up to 5 multicouplers have been successfully cascaded without degrading the signal below acceptable limits. For each installation, at least one installed spare multicoupler is necessary to permit the manual cascading of multicouplers and to provide backup for a defective unit. Where large groups of multicouplers are employed, there should be one installed spare for every ten multicouplers. Multicouplers and installed spares should be distributed as shown in figure 5-4. When the multicoupler is installed cascaded, the input to the cascaded multicoupler does not appear on the RF patchboard.

Multicouplers are installed in groups by antenna types in CY-597A/G or CY-2675 standard equipment cabinets and each multicoupler is identified with the antenna to which it is normally connected. Multicouplers within a group are numbered in sequence from the upper left, top to bottom of each cabinet.

5.6.2 Normal Receiver Station Antenna RF Distribution

Antenna outputs are normally distributed as shown by figure 5-5. The patching equipment and RF multicouplers are normally collocated within the receiver building. All antenna transmission lines enter the receiver building through the cable vault where any necessary reduction in cable size or change of cable type takes place. RF distribution within the receiver building is usually accomplished with a smaller diameter cable than that used from the antenna to the building.

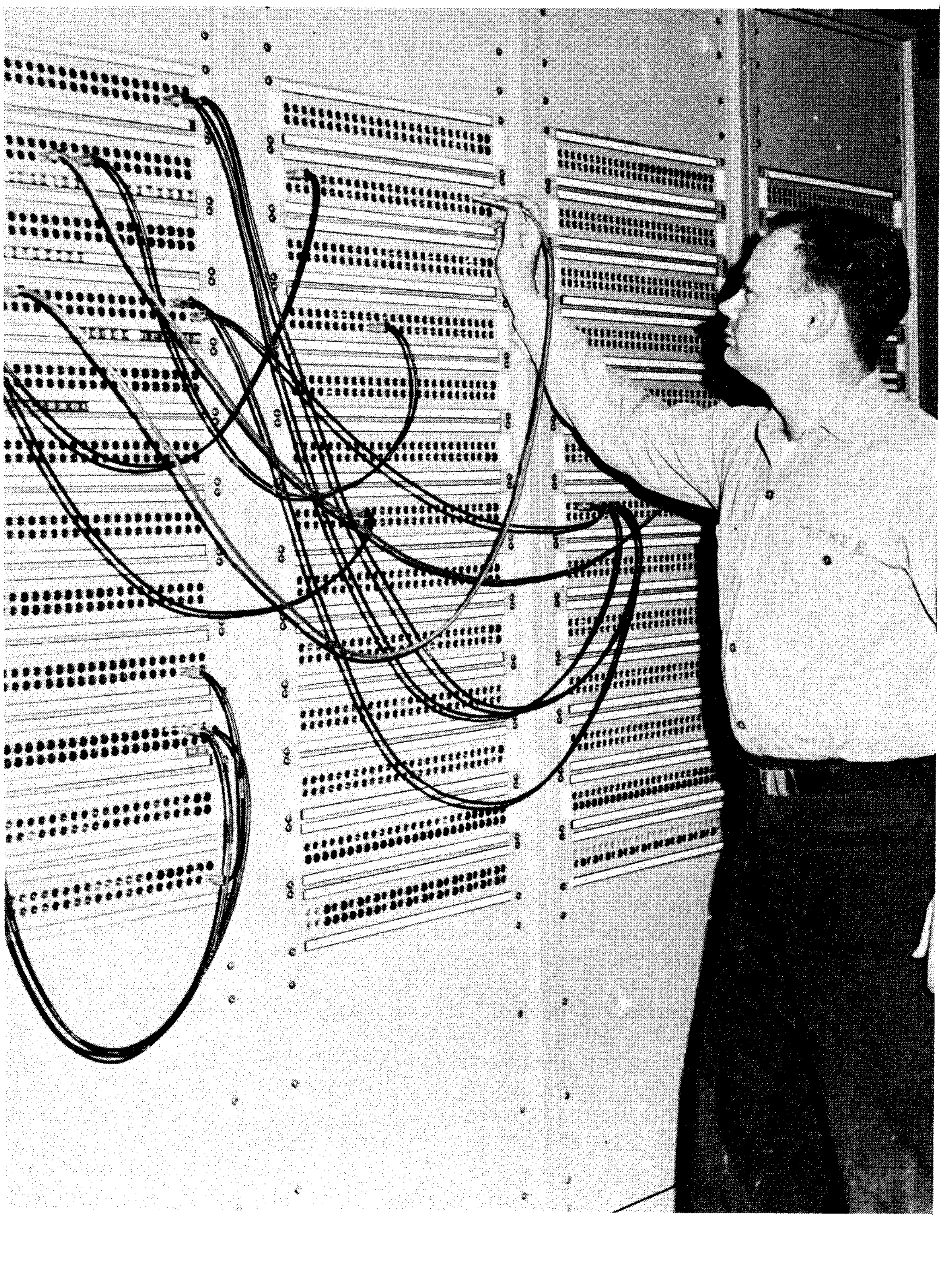


Figure 5-3. RF Receiver Coaxial Patchboard

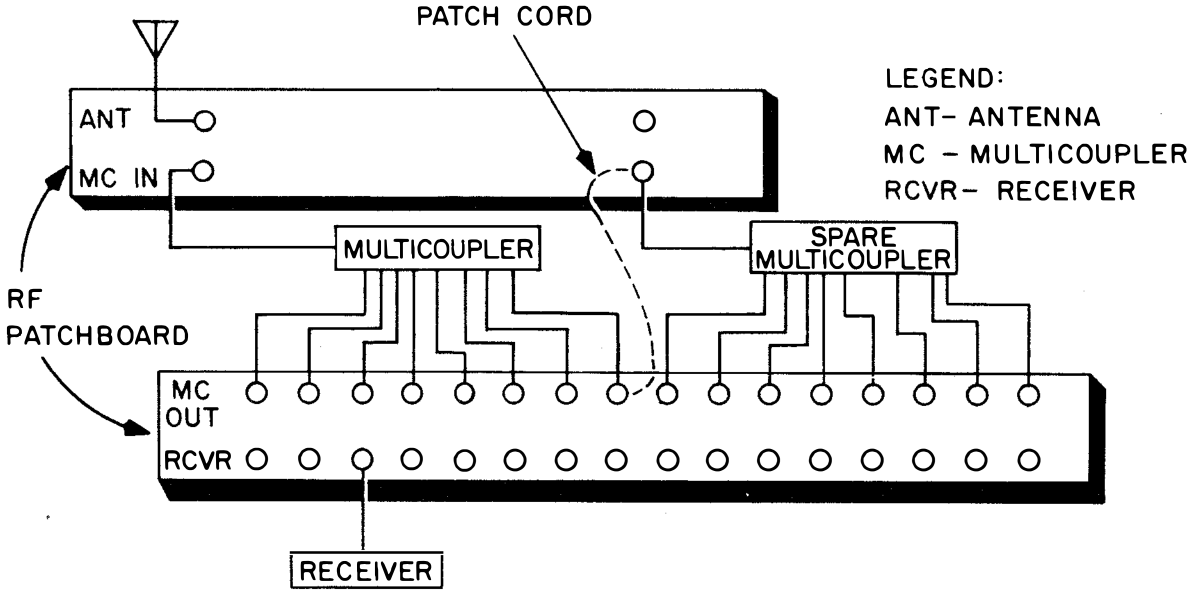


Figure 5-4. Multicoupler and Spare Multicoupler Installation

5.6.3 Wullenweber Antenna RF Distribution

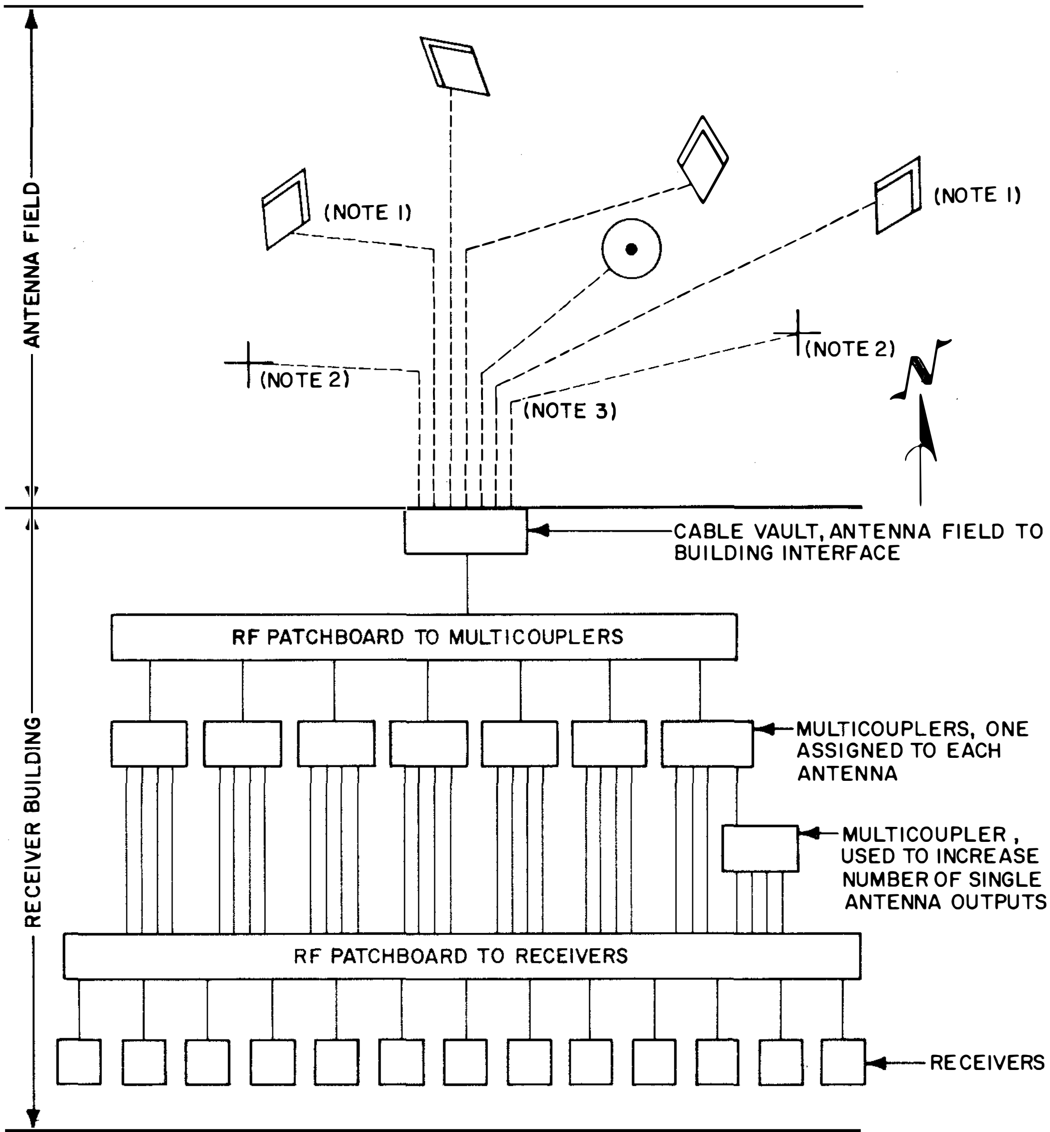
The Wullenweber antenna, used for communications, is a multiple-function receiving antenna array than can produce simultaneously an omnidirectional pattern and several directional beams. The array consists of numerous vertical antennas symmetrically located around a cylindrical screen. All of the antennas are connected to multicouplers with transmission lines precisely cut to equal electrical lengths so that the phase delay will be the same for all lines. The outputs of these multicouplers can be used in the following ways:

a. To select an individual antenna for a specific receiver.

b. To combine selected antennas to operate as an omnidirectional antenna.

c. To combine signals from several selected antennas through beam-forming (delay-line) networks to produce a high-gain directional beam pattern.

Several beam-forming networks are included so that a corresponding number of beams are formed. These beams are aimed in appropriate directions to meet operational requirements. Thus, several options are available for antenna and receiver combinations. The omnidirectional pattern, one of several beams or any individual antenna can be selected for use with any receiver. Figure 5-6 is a simplified drawing of the RF energy distribution from a communications-type Wullenweber array. Descriptions of various Wullenweber antennas are given in NAVELEX 0101,104 — "HF Radio Antennas Systems." Additional information on Wullenweber antennas, related to criteria for naval security group sites, will be included in a future publication.



NOTES:

1. NESTED RHOMBICS POINTED IN SAME DIRECTION AND USED FOR SPACE DIVERSITY
2. SECTOR LOG-PERIODICS POINTED IN SAME DIRECTION AND USED FOR SPACE DIVERSITY
3. EACH ANTENNA HAS ITS OWN TRANSMISSION LINE. TRANSMISSION LINES ARE GROUPED TO SIMPLIFY ROUTING THROUGH ANTENNA FIELD.

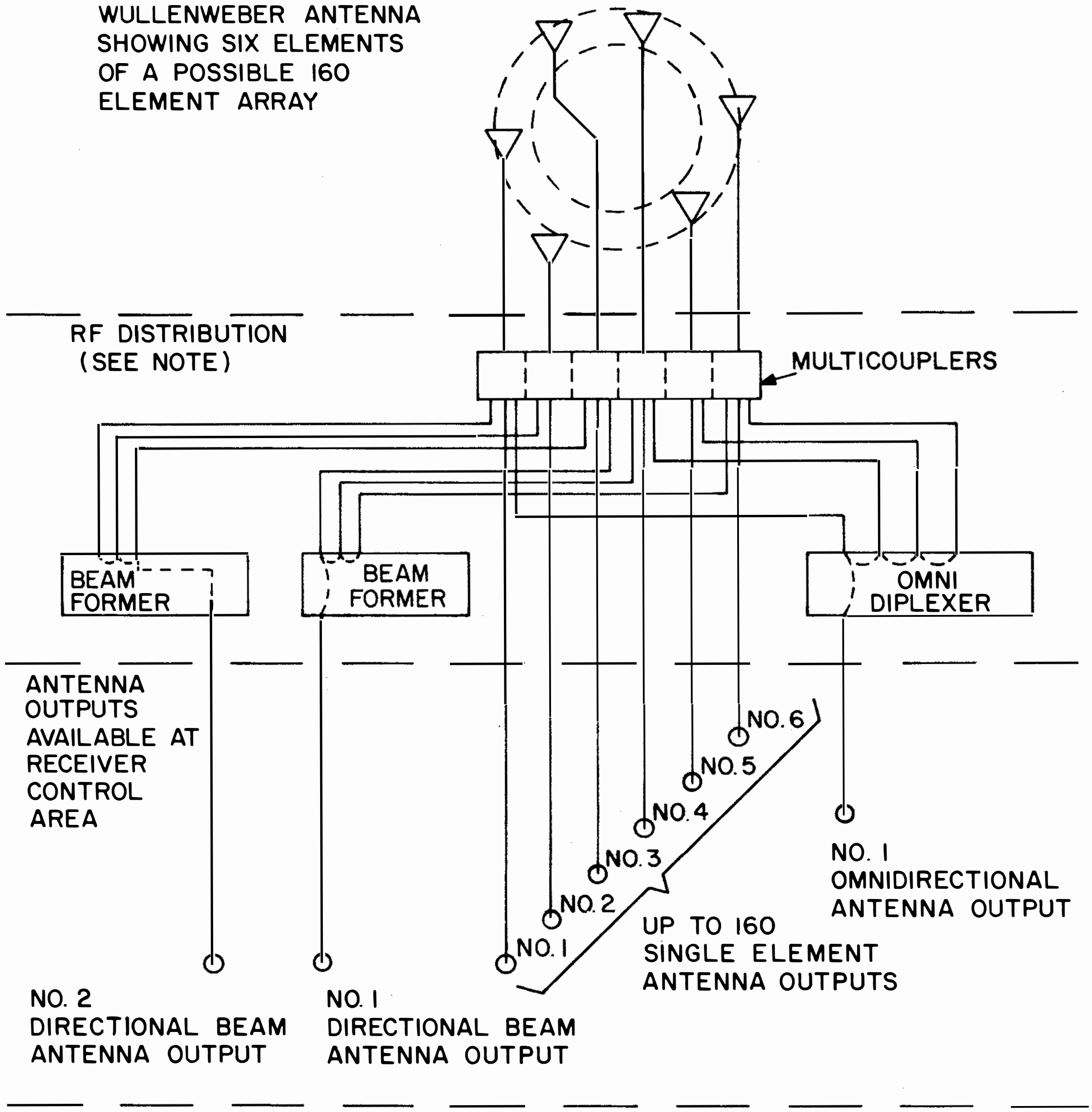
LEGEND:

NESTED RHOMBIC ANTENNA

CONICAL MONOPOLE ANTENNA

SECTOR LOG-PERIODIC ANTENNA

Figure 5-5. Normal Receiver Station Antenna RF Distribution



NOTE: EACH OF THE 160 ELEMENTS FEED THE RF DISTRIBUTION IN A SIMILAR MANNER, ADDITIONAL BEAM AND OMNIDIRECTIONAL UNITS ARE INSTALLED IN ACCORDANCE WITH OPERATIONAL REQUIREMENTS.

Figure 5-6. Typical Wullenweber Array RF Output Capabilities

5.7 RECEIVER SUPERVISORY AREA

A centralized receiver supervisory area is required for each receiver station. This area is to include facilities for all elements of receiver control other than receiver tuning and initial turn-on. The following equipments and controls are in the supervisory area:

a. Circuit patchboards (both audio and DC) for each receiver output and for each channel of the communications link between the communications center and the receiver station.

b. RF patchboards that include antenna outputs, multicoupler inputs and outputs, and receiver RF inputs.

c. A display to show antenna assignment and receiver circuit employment. This display may be provided by on-site personnel or, in the case of large complex systems, it may be part of the installed equipment and it may include an automated updating capability.

d. Controls for directing rotatable-type antennas such as the rotatable log-periodic (RLPA). Since RLPA antennas are used to meet specific operational requirements, multicoupling of a particular RLPA for other than its intended operational application is discouraged.

e. Teletype and voice communications equipment to coordinate operations with the communications center and within the receiver building.

f. Monitoring receivers to facilitate supervision and control.

g. A central time and frequency standard to control the frequency synthesizers of individual equipments. This standard is being implemented as funds become available. The control frequencies are distributed through small coaxial cables which may be routed in the same trays and ducts in which signal and control cables are routed.

5.7.1 Supervisor's Console

The supervisor's console may range from a desk at smaller stations to an automated console at a large complex installation. The supervisor's console must be centrally located with the above listed equipments and functional controls. When special operational difficulties are anticipated, specific items of this equipment may be incorporated within the console itself.

An example of a special console, shown in figure 5-7, is the one installed at the receiver station, Sugar Grove, West Virginia. This station has a switching matrix to switch receiver RF inputs to the individual elements of the Wullenweber antenna array or to the various beams and omnidirectional RF outputs derived from the Wullenweber. The console incorporates control of this matrix and includes readouts from a sensing system within the matrix that show the signal levels of individual antennas. The console operator selects the antenna receiving the best signal.

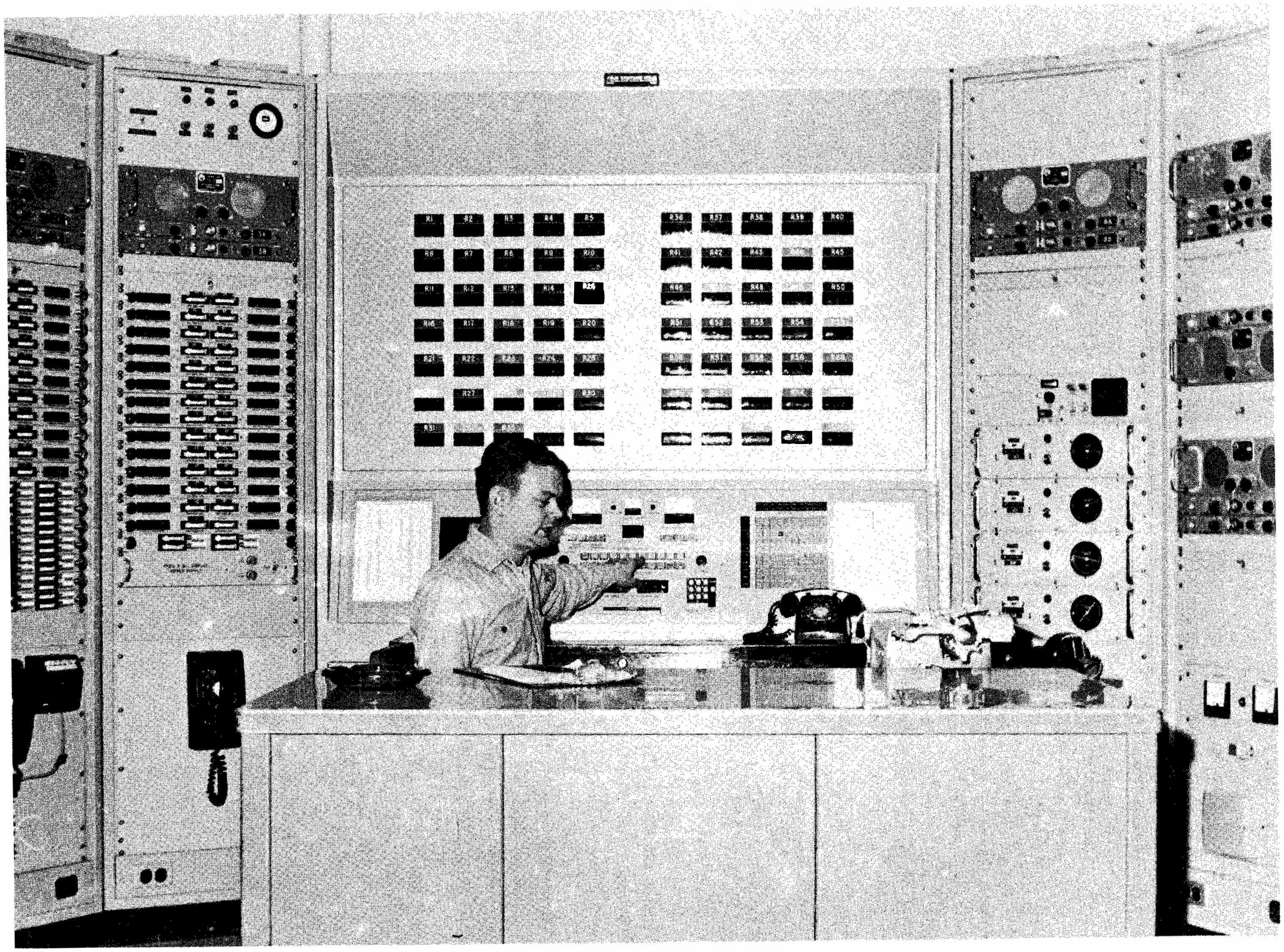


Figure 5-7. Supervisor's Console, Sugar Grove, West Virginia

5.7.2 Receiver and Circuit Control

Receiver and circuit control is accomplished through the use of equipment in the supervisory area. Receivers are connected to antennas through the coaxial patchboards or switching matrices as required by the operational situation. The patchboards or switching matrices permit rapid substitution of equipment, monitoring without circuit interruption, and testing of lines and equipment. The test and monitoring equipment may be portable or part of the installed patchboard facilities. The patchboards terminate all signal lines to and from the receiver building and inputs to and outputs from all receivers and associated equipments. Chapters 3 and 9 also discuss distribution of signals within a building.

Orderwire circuits between the receiver supervisory area and the communications center are used to exchange information concerning circuit and equipment usage. Orderwire information is usually transmitted via a teletype system because this system inherently provides a written record of all messages transmitted and received. The keyboard equipment and teletype page printers are located in the supervisory area and may be incorporated within the supervisor's console.

5.8 TRANSCEIVERS

Tranceivers, or separate transmitters and receivers, for the frequency ranges of 132-152 and 225-400 MHz may be located within the receiver building if the power output is less than 100 watts. This type of equipment is normally used for administrative purposes in communicating with maintenance, fire protection and security forces located in remote areas of the station. However, some receiver stations use this equipment for short range (line-of-sight) and point-to-point communications services in support of the mission of the station.

When used in support of the mission of the station, this equipment is engineered in a manner similar to an intersite link. All circuits supported by the system are routed through the station's patchboards and distribution frames. All technical control functions are performed from the receiver control area.

When transceivers are used for administrative purposes the circuit routing should be separated from those circuits dedicated to the mission of the station and should not be run through the patchboards or the main or intermediate distribution frames. Control and operating positions for this equipment should be located in a space other than the receiver room.

5.9 EMERGENCY COMMUNICATIONS

For emergency communications HF transmitters may be installed in a receiver building. Transmitters for this purpose are normally of less than 100 watts power output and usually radiate from a whip antenna on the roof of the building. Dummy loads must be provided for testing these transmitters since on-the-air testing is seldom permitted. Any such transmitters are normally located in a room other than a receiver room.

5.10 CONSTRUCTION AND INSTALLATION

Receivers and their associated equipments are adaptable for installation in most existing structures. The controlling criterion for the structure is that it must provide an acceptable environment for the equipment and personnel. Receiver buildings are usually permanent structures; however, in overseas areas on foreign soil, current DOD instructions state that communication facilities be transportable rather than permanent structures. When new construction is contemplated the general criteria of chapter 7 and the specific criteria of this section are applicable to the receiver building.

5.10.1 Receiver Building Features

a. The building must be a rectangular single floor structure.

b. The receiver room and rooms for other electronic equipment must be windowless and free from obstructions.

c. The floor may be concrete, and it must be designed to support a loading of 150 pounds per square foot.

d. The equipment rooms must have a 10-foot clearance between floor and ceiling. This clearance must be maintained when raised floors and suspended ceilings are installed.

e. The electronics maintenance shop must contain a screen room, measuring about 10 by 15 feet, that provides 60 dB attenuation in the frequency range of 10 kHz to 100 kHz.

f. Cable vaults are required to serve as the entrance for all antenna transmission lines.

5.10.2 Receiver Building Lighting

Fluorescent lighting may be used in the receiver building and in the receiver room when the fixtures are equipped with power line filters and are grounded with the green, third wire of the power line feeder.

5.11 EQUIPMENT ARRANGEMENT AND LAYOUT

Equipment is placed so as to promote operator efficiency and to ensure sufficient space for maintenance accessibility. A standard layout has not been established because station operational requirements differ greatly. A layout with the operating equipment surrounding the supervisor's control area is the most desirable arrangement. At smaller stations all receiving and associated equipment can be observed from the supervisory area. Figure 5-8 shows an example of a small station layout. In this example the station is in one room of a building; space required for personnel and support services is not shown. At larger stations the quantity of equipment installed precludes such a simple layout, but the general principle should be followed as far as possible. In a large station equipments must be assembled in lines facing

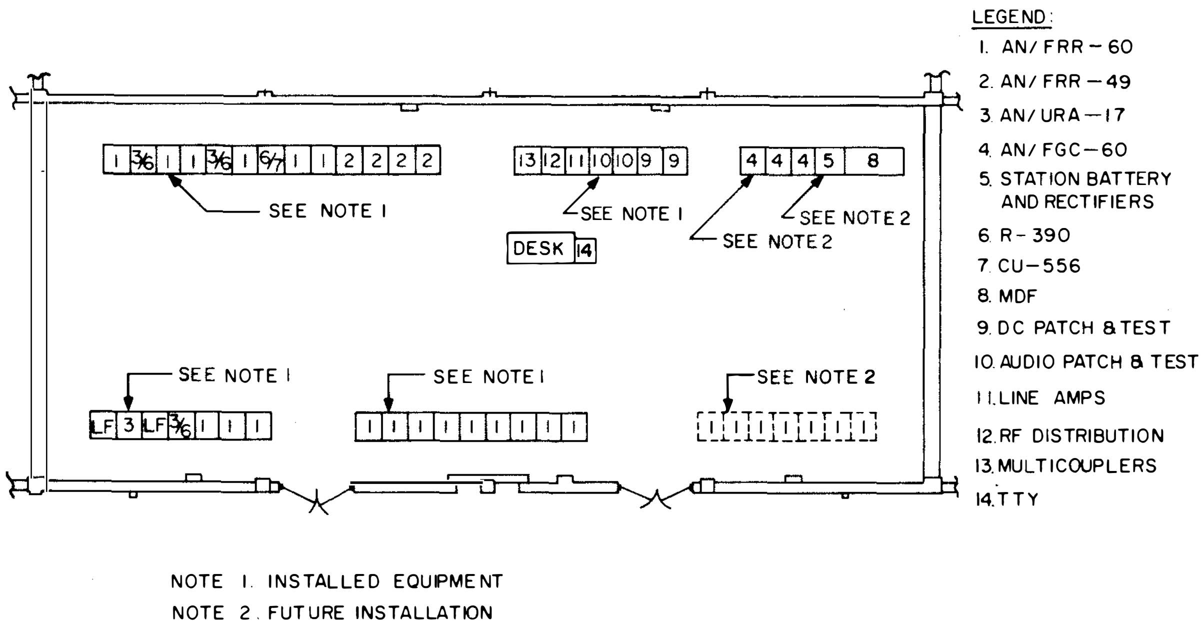


Figure 5-8. Receiver Room, Small Receiver Station

front-to-front. Between the fronts there must be a minimum of 6.4 feet to form an aisle which will be accessible to operators and maintenance crews. Figure 5-9 shows an example of the layout for a large station specifically designed for receiving purposes.

5.12 RECEIVER BUILDING GROUND

Receiver building and equipment grounding has been investigated by the Naval Electronic Systems Test and Evaluation Facility, St. Inigoes, Maryland. The conclusions were:

a. The controlling factor affecting RF signal reception is external noise (atmospheric, cosmic and man-made) entering the receiver via the antenna.

b. A very low resistance earth ground connection is expensive to install, hard to maintain and adds nothing to the operational efficiency of a modern receiver.

c. Bonding and grounding of all structural metal which is no longer than 24 inches is of value only when reradiation of a signal is deemed to be a possibility.

The recommendations of this report have been accepted as the grounding criteria for the receiver building, provided Red and Black processing (exclusive of orderwire traffic) will not be required. When Red and Black circuit processing is to be accomplished within the receiver building the signal grounding system must be in accordance with the latest issue of NAVELEX Instruction 011120.1. A discussion of Red and Black signal grounding is also included in chapter 12.

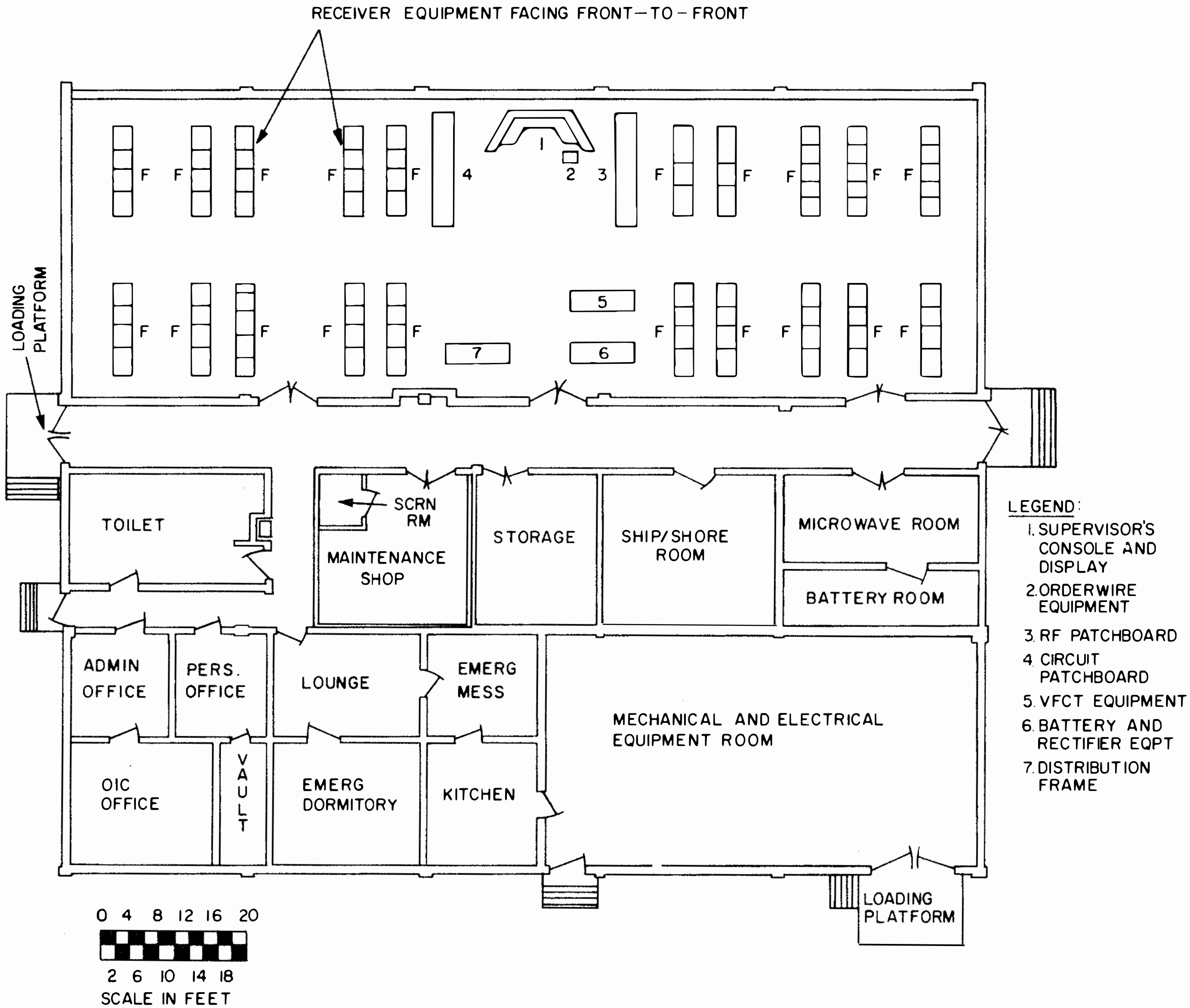


Figure 5-9. Receiver Building, Large Receiver Station

The following criteria govern the grounding system of the receiver building the location of which presumed to be as recommended, provided that the building is not collocated with a transmitter site.

a. One ground connection point will be used. Separate earth ground points for electrical and communications systems will not be used.

b. Resistance of the ground system to solid earth must comply with the provisions of article 250-84 of the National Electrical Code which requires a resistance to ground of not more than 25 ohms.

c. Bonding and grounding of structural metal which is longer than 24 inches is not normally required. Such a requirement is to be treated on an individual case basis.

5.12.1 Receiver Building Earth Ground Connection

A good earth ground connection can be established by selecting a grounding electrode recommended in articles 250-81, 250-82, and 250-83 of the National Electrical Code Handbook (NECH), 1968, which states than an underground water piping system, either local or one that supplies a community, is preferred as the ground point. This handbook permits other ground point possibilities such as the metal frame of a building, other underground pipe or tank systems (exclusive of gas service piping), and electrodes installed in the ground. A general discussion of installed electrodes, together with recommended test methods, is found in chapter 12.

5.12.2 Receiver Building Ground Distribution Systems

The ground distribution system in the receiver building emanates from a ground bus that is connected to the selected earth ground connection point. All ground systems must be terminated on this common ground bus.

5.12.3 Ground Bus to Earth Ground Point Interconnection

The accepted criteria for the connection between the ground bus and ground point for the receiver building are:

a. Connection between ground bus and earth ground point must be made with a conductor that runs either directly to the earth ground point or to the main electrical service entry point ground lead which is in turn run to the earth ground point.

b. The size of the conductor connecting the bus and earth ground point must not be less than that specified by article 250-94 of the NECH. Number 6 copper wire, or its equivalent, in ampere rating capacity is sufficient to connect to any electrode installed to serve as the ground point.

c. The conductor connecting the ground bus to the earth ground connection point must be attached by a suitable ground clamp, a terminal screw, or a pressure connection.

5.12.4 Ground Bus to Equipment Distribution

The accepted criteria for the ground distribution between equipment and the ground bus for the receiver building are:

a. All electronic equipments and component parts of an electronic system must be provided with a separate grounding conductor to connect the electronic equipment to the ground connection point. This conductor is normally the third wire, green AC protective ground, provided as part of the power feeder.

b. Grounding conductors must be routed with circuit power conductors from electric distribution panelboards to the cabinet or rack that houses electronic equipment.

c. Grounding conductors must have a green covering with or without yellow stripes.

d. The grounding conductor must be the same size as the power conductors with which it is routed.

5.12.5 Ground Conductor Termination

The accepted criteria for terminating the ground conductor to electronic equipments in the receiver building are:

a. The grounding conductor must be terminated directly to the ground terminal (if provided) on the electronic equipment. This type of installation can be accomplished easily when a single power feeder supplies power to an individual equipment.

b. If grounding terminals are not provided on equipments, grounding can be a accomplished by bonding the ground wire to the equipment encosure.

c. When several equipments are mounted in a cabinet or rack and power is supplied by a single power feeder, a ground bus such as that shown in figure 5-10, should be installed to facilitate grounding. The following restrictions and procedures apply to this installation:

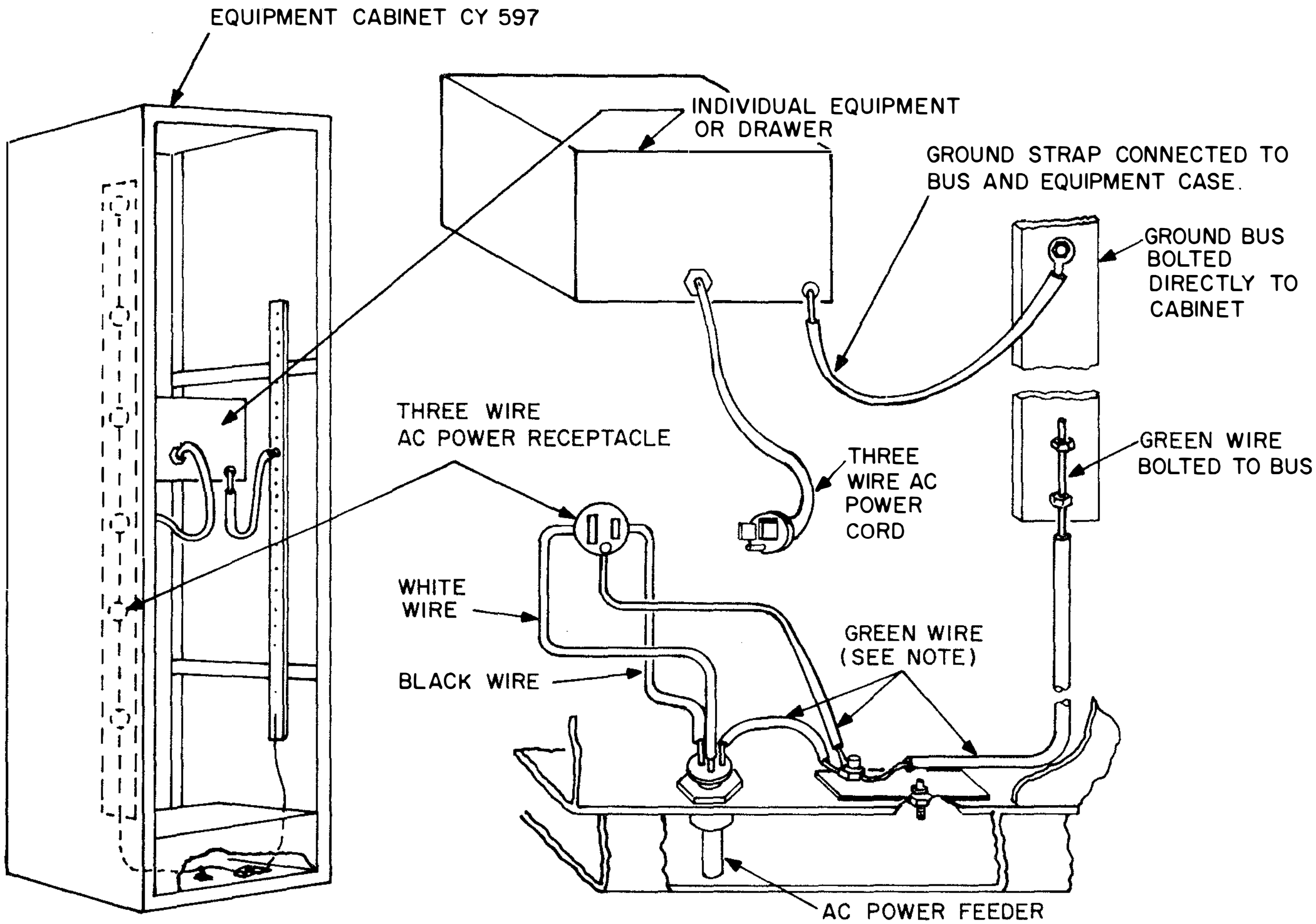
(1) The bus should be of highly conductive metal. (Copper is preferred.)

(2) The bus should be provided with easy access points so that equipments can be grounded easily.

(3) The ground conductor should be bonded to the bus.

(4) Bonding between the ground bus and equipment must be accomplished using approved bonding techniques.

(5) The third wire (green) of the AC plug and power cord is retained but does not by itself meet the grounding requirement.



NOTE: SIZE OF GREEN WIRE CONDUCTOR TO BE SAME OR LARGER THAN THAT OF AC INPUT.

Figure 5-10. Typical Equipment Cabinet Grounding Detail

5.12.6 Ground System Testing

The connections of the grounding distribution system should show a resistance no greater than 0.5 ohms between the following:

a. Equipment ground (terminal or enclosure) and grounding electrode (ground wire leading to equipment).

b. Equipment ground (terminal or enclosure) and ground bus of the AC power source (grounded neutral of the power feeder).

c. Equipment ground (terminal or enclosure) and cabinet or rack in which it is installed.

d. Equipment ground (terminal or enclosure) and all other grounding systems within the building.

5.13 SITING

The general geographic site for the receiver station is selected based upon the operational requirements and the adaptability of the site for receiver purposes as discussed in NAVELEX 101, 103 — "HF Radio Propagation and Facility Site Selection." Table 5-3 is the accepted criteria which establish the minimum distances for separating the receiver building and its associated antenna park from possible interference sources. This table is applicable once the general geographic location has been selected. The receiver building must be located in the center of the antenna park. When a station is erected, the reasons for selection along with initial background noise measurements must be recorded for future reference. This recorded information provides a base line for future evaluation of requests to permit other facilities to encroach upon the receiver location and for determination of the seriousness of any noise pollution problems.

A receiver station must be protected from encroachment by establishing a protective corridor and a legal restricted area, each one mile wide as shown in figure 5-11. The protective corridor is located within the station boundary and can be used for installation of temporary antennas. The legal restricted area is a land area surrounding the boundary of the station in which it is illegal to develop the land in any way that would be detrimental to the mission of the receiver station. Constant vigilance is required to maintain the "status quo" once the legal restricted area is established.

5.14 INTERFERENCE

One of the most important factors to consider when siting or installing receiver systems is to minimize the effects of interference. This applies to self-generation of radio interference as well as provision against external interference. Poor installation and poor maintenance practice can result in the existence of high levels of radio interference even though the original installation was not located in an area of high radio interference levels. This condition is caused by the subsequent installation and operation of radio interference sources in proximity to a receiving activity without taking corrective action towards rendering these sources ineffective by means of shielding or filtering as necessary.

Table 5-3. Receiver Station Separation Distances

SOURCES OF INTERFERENCE	MINIMUM DISTANCE
High-power transmitter stations:	
Very low frequency	25 mi
Low frequency/high frequency	15 mi.
Other transmitters not under Navy control	5 mi.
High-voltage power transmission lines 100 kV or greater	2 mi*
Receiver Station power feeders	1000 ft from nearest antenna
Airfields and glide paths:	
For general communications	5 mi
For aeronautical receiving at air station	1500 ft
Teletype and other electromechanical systems:	
Low level operation or installed in shielded room	No minimum
High level operation installed in unshielded room	
Large installation (communications center)	2 mi from nearest antenna
Small installation (1 to 6 instruments)	200 ft from nearest antenna
Main highways	1000 ft
Habitable areas (beyond limits of restriction)	1 mi
Areas capable of industrialization (beyond limits of restriction**):	
Light industry	3 mi
Heavy industry	5 mi
Radar installation	***
Primary power plants	5 mi

*The following NAVELEX requirements also govern distances to non-Navy transmitter stations:
—Signal from non-Navy station shall not exceed 10 millivolts per meter (field intensity) at Navy site boundary.
—Harmonic or spurious radiation from non-Navy station shall not exceed 5 microvolts per meter (field intensity) at Navy site boundary.

**The restriction limit is the protective corridor i. e. that area between the outer limits of the antenna field and the site boundary.

***Calculate using "Electromagnetic Prediction Techniques for Naval Air Stations," White Electromagnetics, Inc., Rockville, Maryland, NObsr 87466.

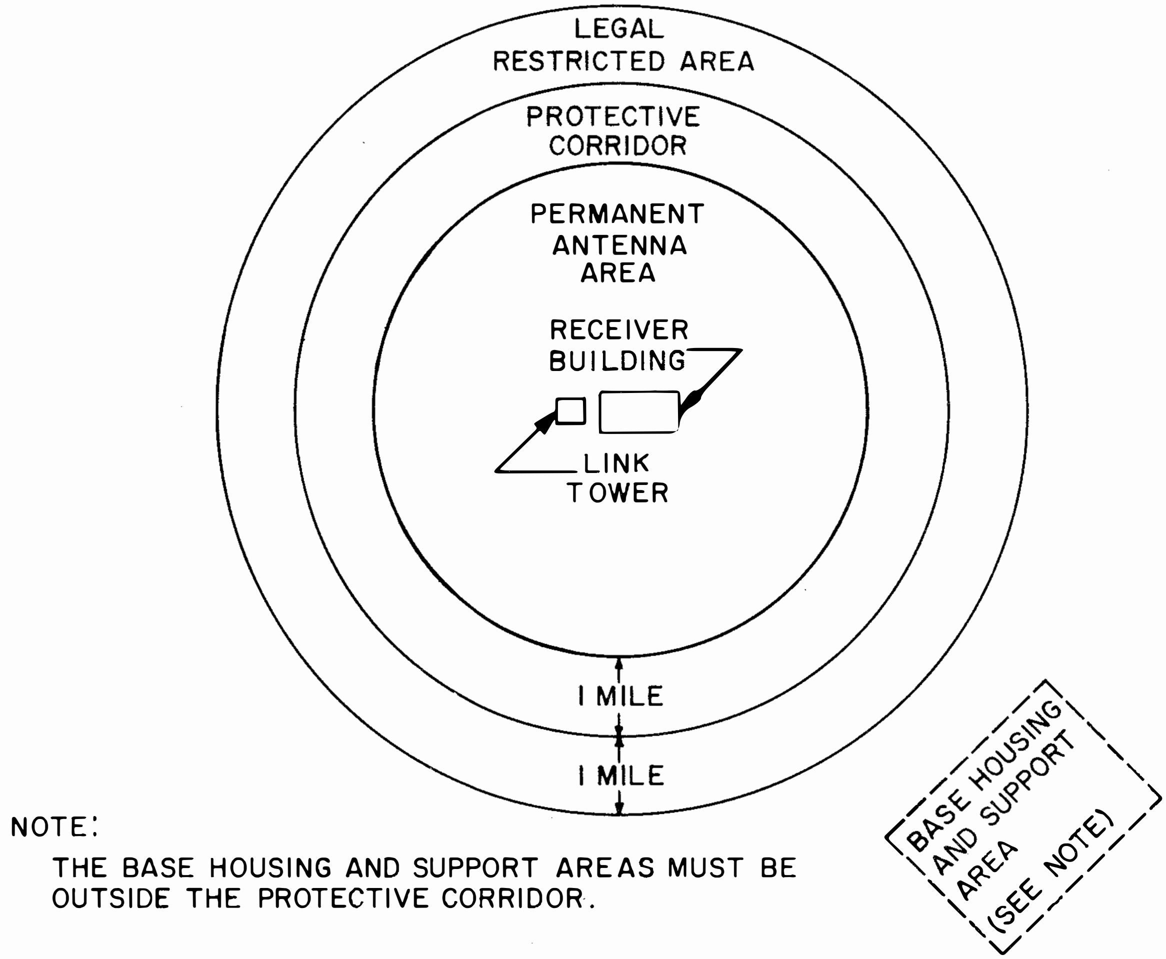


Figure 5-11. Receiver Station Site Plan

The best time to minimize future sources of interference is in the initial planning stages. Periodic checks of local activity near the receiving facility should be performed to verify that separation distances specified in table 5-3 will not change. Often, if local authorities can be convinced of the need for restrictions, potential interference can be averted.

Man-made noise appears to be increasing on an exponential curve. Therefore, at all existing sites periodic noise measurements should be made for future reference. A record of noise intensities could aid in solving encroachment problems and may help in isolating sources of new man-made interference problems.

CHAPTER 6

INTERSITE COMMUNICATIONS LINKS

6.1 GENERAL

Communications channels are required to link the communications center with the receiver building, transmitter building and any other locations that may be serviced by the communications center. The intersite communication links provide the necessary channels between locations. All information carried over the links is in an unclassified form and the primary flow is from the communications center to the transmitter building and from the receiver building to the communications center. In addition, two-way traffic is carried between the locations for control and coordination of the communications resources.

Information is carried over the links in standard 4-kHz bandwidth audio circuits when the distance between locations exceeds two miles or when the transmission of DC signals is not reliable due to high RF radiation or background noise. DC signals are transmitted as VFCT tone groupings on 4-kHz audio circuits. The 4-kHz audio circuits may be provided by a local telephone company or by a Navy-owned microwave system. Except at overseas locations on foreign soil a military-owned telephone system must be used rather than the local telephone company. The DCS transmission standards for the 4-kHz audio circuit are contained in DCAC 330-175-1.

6.2 LINK SELECTION

The link system to be used between sites is determined by cost study compared with a careful evaluation of the requirements. A combination of DC and audio circuits may be satisfactory and is often used. The cost study may conclude that a telephone company service is preferred, but communications security requirements or space availability may dictate the selection of another system. For example, a separate room or building for the telephone company equipment is always required; this could be the controlling factor in selecting the type of link to use.

6.3 LINK INTERFACE

The main distribution frame is the point of interface between the link transmission system (microwave, telephone or DC) and the other communications facilities in the building. Each individual send and receive channel of the link system is terminated on the main distribution frame from which the channels are routed for further processing or distribution.

6.4 NAVY-OWNED MICROWAVE INTERSITE LINKS

Navy-owned microwave intersite links are wideband, line-of-sight, transmission systems. Frequency division multiplexing methods are used for the simultaneous transmission of information on 4-kHz bandwidth channels in either or both directions.

Microwave systems currently in use operate in the frequency bands of 1700 to 1850 MHz, 2200 to 2300 MHz, and 7125 to 8400 MHz and can accommodate up to 600 4-kHz channels. To ensure link reliability, most Navy installations have two continuously radiating transmitters and two operating receivers at each terminal. At a given microwave terminal either of the operating transmitters is fully capable of maintaining circuit continuity to the distant terminal, and either receiver is fully capable of receiving all information from the distant terminal.

6.4.1 Microwave Propagation

Microwave RF energy travels in a direct path from the transmitting antenna to the receiving antenna; however it can be reflected from the surface of the earth or any other reflecting surface. The reflected energy often arrives out of phase with respect to the direct wave and may cause cancellation and serious fading of the received signal. Earth-reflected energy is particularly bothersome at operating frequencies between 1000 and 3000 MHz. Above 3000 MHz earth reflections become less serious since the small irregularities of the earth's surface, such as rocks, become an appreciable part of the wavelength and scatter the energy instead of reflecting it. Because of this scattering, a strong reflected signal does not arrive at the receiving atnenna. At frequencies above 10,000 MHz raindrops or snowflakes can cause high attenuation of the signal since their diameters may be one-half of a wavelength or more at the frequency of the transmitted RF energy. The drops or flakes thus short-circuit the electric field, and the energy is dissipated as heat. A water surface between transmitting and receiving antennas forms a poor microwave path because the smooth surface is an excellent reflector. Rough terrain makes a better microwave path than does a smooth surface, since the surface irregularities refract and scatter the reflected energy. A high-low antenna siting technique is one method of causing the refracted energy to be reflected away from the receiving antenna when propagation is over water or smooth earth. Figure 6-1 illustrates this technique for both water and smooth earth.

When a direct line of sight can not be selected, it is possible to use passive reflectors or back-to-back parabolas to alter the direction of transmission. A change of transmissions direction might be dictated to avoid interference with other services or to avoid an obstacle in the path between stations. A plane reflector can be used when the stations are located so that the signal will "bounce" off the reflector onto the receiving antenna. Plane reflectors arranged as shown in figure 6-2, may be used to provide a double "bounce," but plane reflectors may not suffice when a very high ridge intercepts the beam. In this latter case, back-to-back parabolic antennas interconnected by a short length of waveguide or coaxial cable can be used. One antenna faces each station.

6.4.2 Path Selection

Due to the fact that microwave energy propagates like light energy, a clear line-of-sight path must exist between the transmitting and receiving antennas of a microwave system. Although the problem appears simple, it must be appreciated that over a path of 20 to 30 miles, it is difficult for an observer to determine the relative elevations along the path. Several methods are available for obtaining a path profile, one way being to consult topographic maps published by the United States Department of the Interior Geological Survey. State indexes and a folder describing topographic maps are furnished free on request. Maps may be ordered by mail as follows:

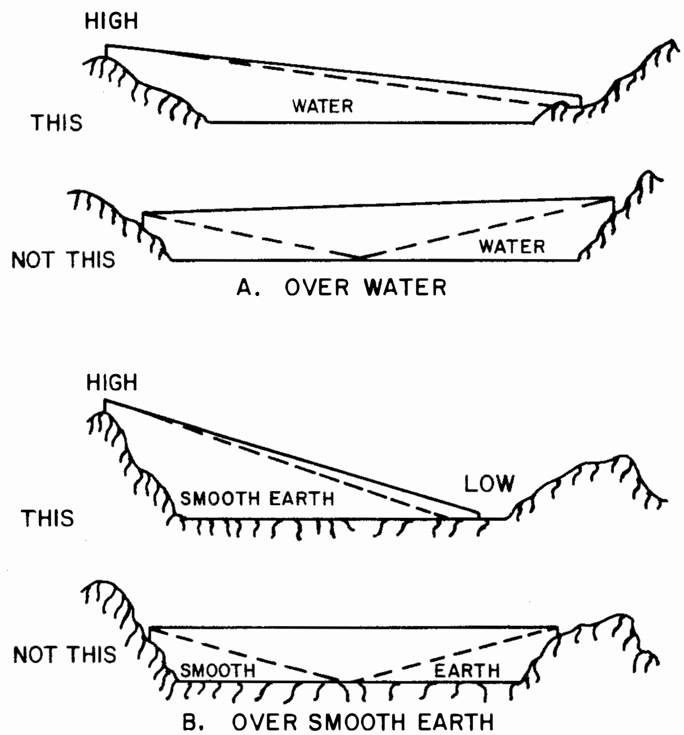


Figure 6-1. High-Low Antenna Siting Technique

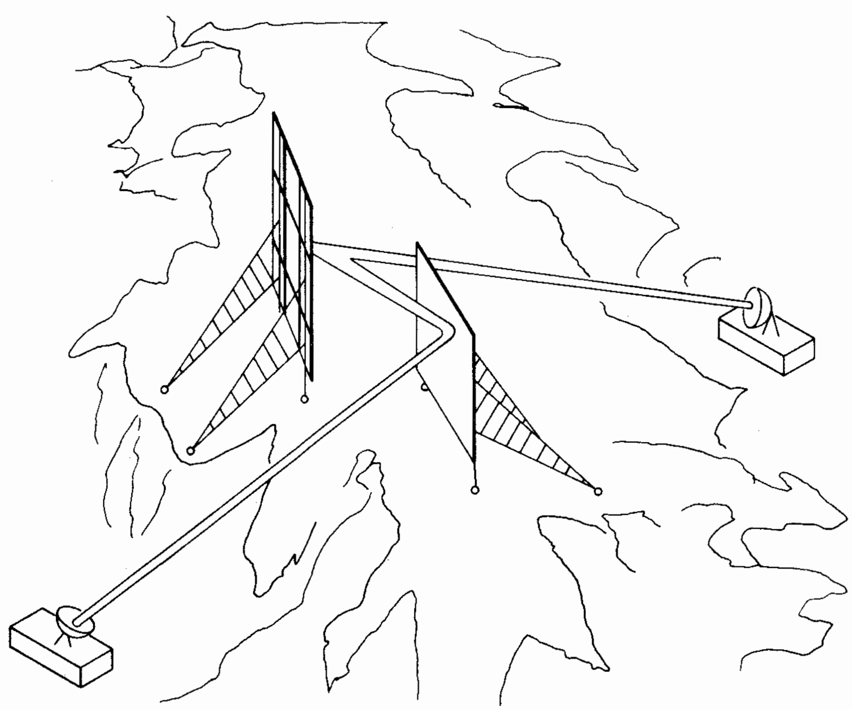


Figure 6-2. Passive Double Reflector

a. For maps of areas west of the Mississippi River, address the Geological Survey, Distribution Section, Federal Center, Denver, Colorado.

b. For maps of areas east of the Mississippi River, address the Geological Survey, Distribution Section, Washington, D. C.

c. For maps of Alaska, address the Geological Survey, 520 Illinois Street, Fairbanks, Alaska.

Further path study will be required because the topographic maps do not show tall buildings or heavy timber growth or other factors that might influence the propagation of microwave energy. A path survey may also disclose that a large flat area shown on the topographic map becomes flooded during spring rains, creating a large water surface along the transmission path. Other methods of obtaining a path profile include surveying with normal surveying instruments, or plotting the readings of a radio altimeter from a helicopter. (An aneroid altimeter is used to maintain the helicopter at a fixed altitude while it is being flown over the proposed path.) One relatively easy test technique is to transmit along the desired path and suspend receiving equipment below a helicopter in the proposed receiving antenna location. The height of the tower required to support the receiving antenna can be determined by locating the strongest signal. A detailed procedure for selecting the most desirable microwave propagation path and determining specific antenna height is the subject of a handbook planned for future publication.

6.4.3 Multiplexing Equipment

Frequency division multiplexing is used with the microwave transmission links. The multiplex equipment combines 4-kHz voice-frequency channels into discrete portions of the microwave link baseband. The current standard multiplex set is the AN/UCC-4 (V) which is similar to the AN/FCC-17, the previous standard. The distinctive difference between the sets is the method of channel modulation. Multiplexer set AN/UCC-4 (V) has a lower-sideband modulation plan requiring 12 channel-carrier frequencies; each channel uses a different carrier. The lower sideband is selected from the channel modulator. See figure 6-3. Multiplexer set AN/FCC-17 has a twin-channel modulation plan requiring only six channel-carrier frequencies; two adjacent channels use the same carrier. The lower sideband is selected for one channel and the upper sideband for the other. See figure 6-4. Another important difference between the two types of multiplexer sets is the frequency and transmission level of the group pilot: the AN/UCC-4(V) pilot is 104.08 kHz at –20 dBm0, whereas the AN/FCC-17 pilot is 64 kHz at –16 dBm0.

The AN/UCC-4(V) is adaptable to station expansion since the equipment capabilities and its power supply capacity may be expanded by adding modules to the basic system. The basic electronic equipment supports from 12 to 60 communications channels and occupies four standard equipment racks. For each 60-channel expansion, two additional racks of equipment are required. The system can be expanded in this manner to reach a total system capacity of 600 channels. A typical floor plan of a 360-channel set is shown in figure 6-5.

The following installation requirements have been established for the AN/UCC-4(V) set.

a. The batteries are to be installed in a separate room from all other equipment.

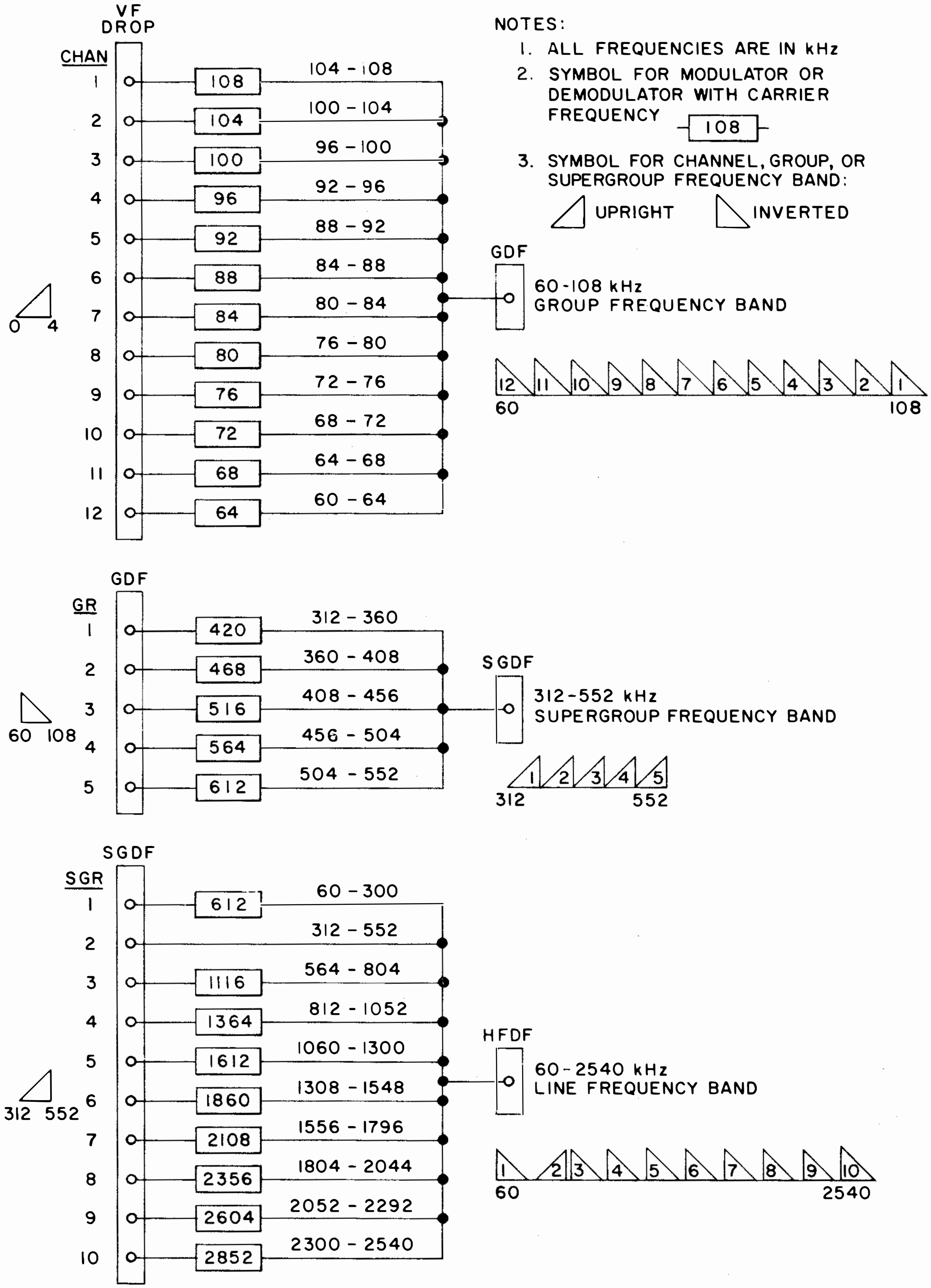


Figure 6-3. AN/UCC-4(V) Frequency Translation Plan

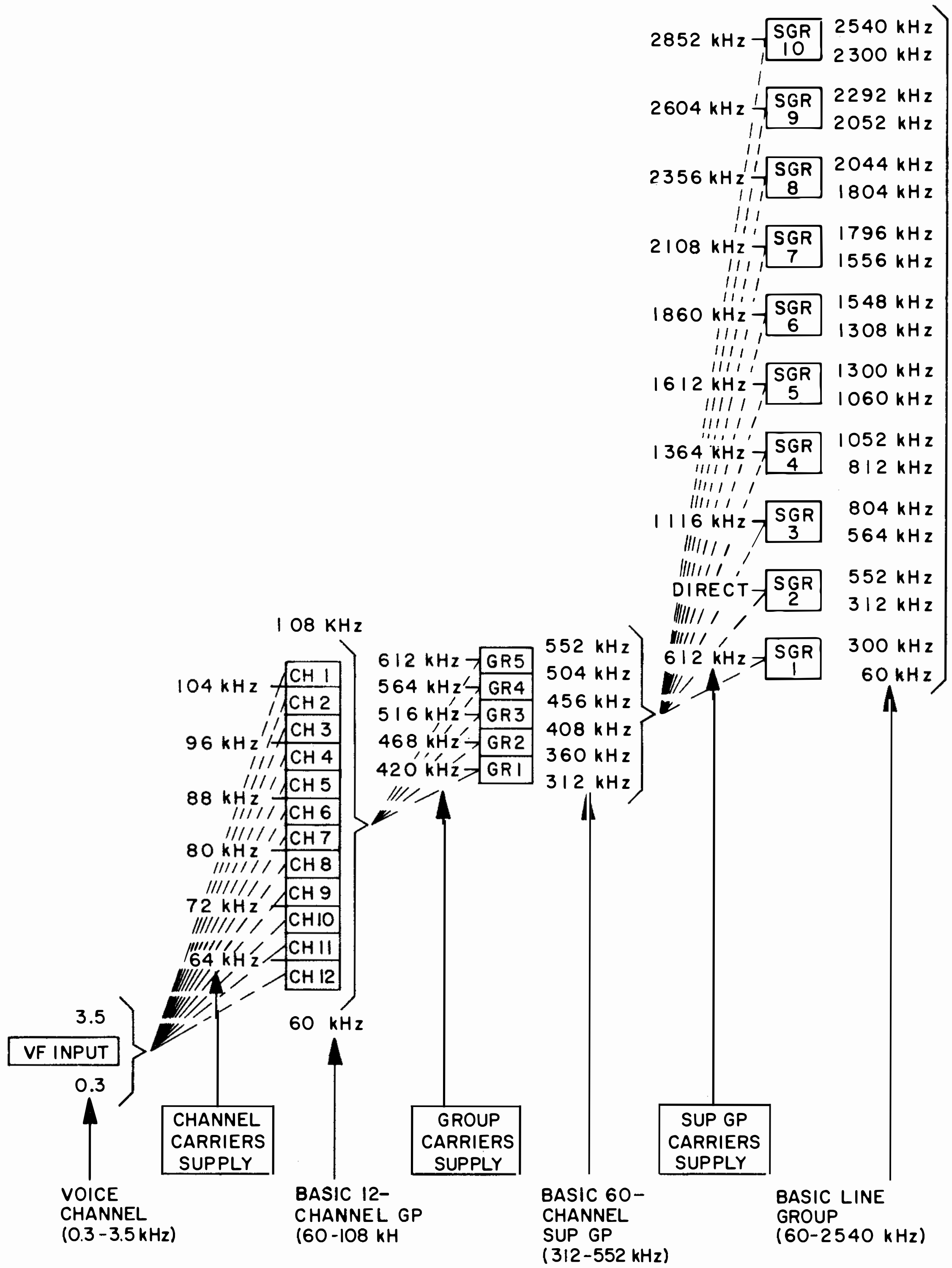


Figure 6-4. AN/FCC-17 Frequency Translation Plan

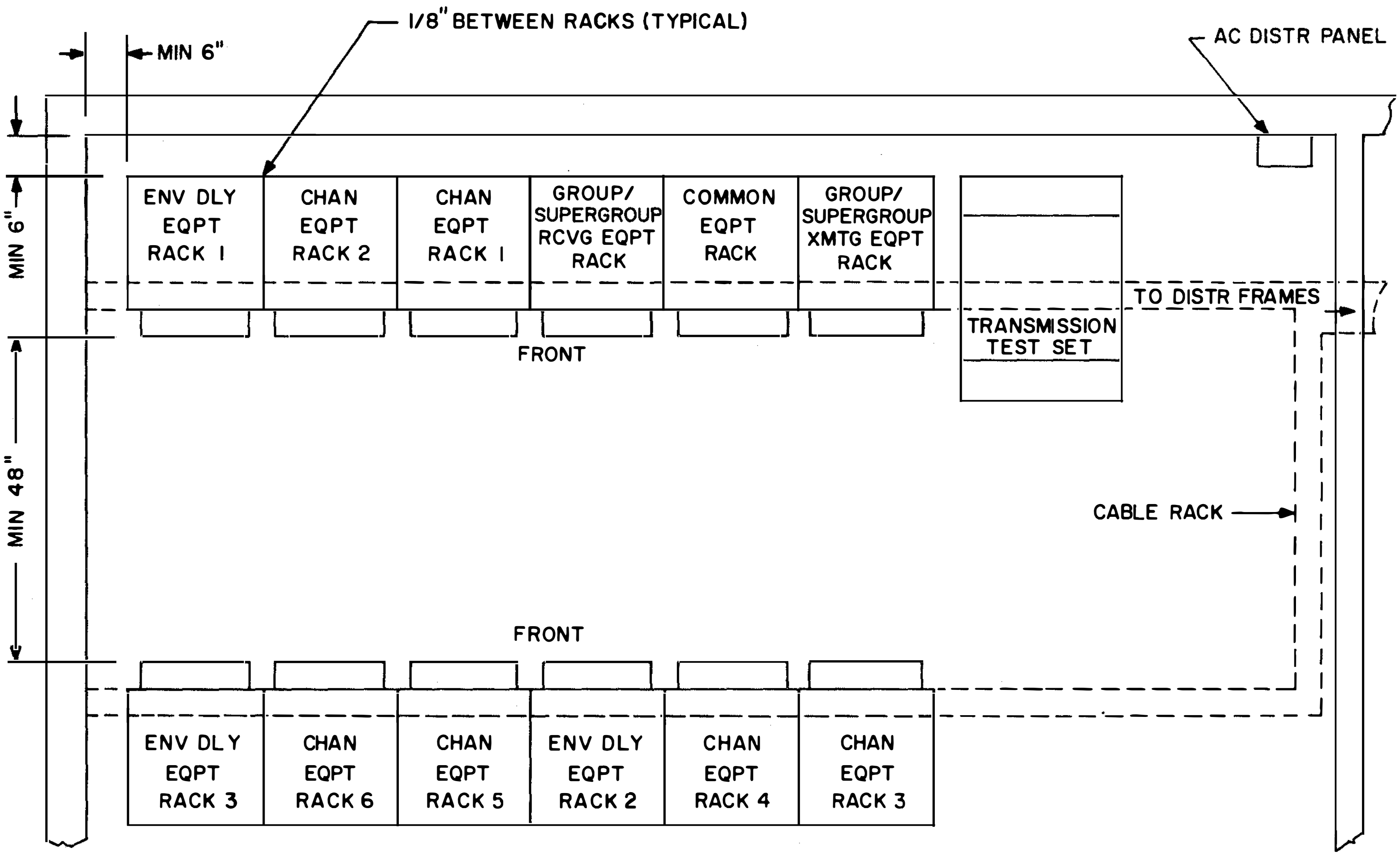


Figure 6-5. AN/UCC-4(V) Typical Floor Plan

b. The battery room is to be supplied with its own ventilation intake and exhaust ports.

c. The central ventilation system supplying air to and exhausting air from the building may be used to service the battery room.

d. A ceiling height of 10 feet and a floor space of 10 square feet should be programmed for each rack of equipment to ensure a sufficient maintenance and operational area.

> NOTE: Most racks measure 90 x 23-1/4 x 20-1/8 inches and require a minimum height clearance of 8 feet and a front clearance of 48 inches.

e. The room temperature should be maintained at 77° F (± 18°) and the relative humidity should not exceed 80%.

f. The set may require RF shielding if it is located near high power radio transmitting equipment. However, the presence of radiated electromagnetic fields up to the following limits are permissible.

(1) 14 kHz to 2.6 MHz: .... 0.1 volt/meter

(2) 2.6 MHz to 100 MHz: .... 0.3 volt/meter

(3) 100 MHz to 10,000 MHz: .... 1.0 volt/meter

6.4.4 Power Supply

Present day microwave systems used by shore stations are furnished a 48-volt DC rectifier charger unit with a floating lead-calcium battery plant connected across the power leads. The batteries will carry the system for 8 hours under full load during AC power failure and the charger unit will restore the batteries to full charge within 24 hours. During normal operation the batteries float on the line with the charger unit serving as the primary power source.

CHAPTER 7

GENERAL CRITERIA FOR BUILDINGS

7.1 GENERAL

Permanent communications station buildings are designed to promote operational efficiency as well as to provide protection and physical security for equipment. Each building is tailored specifically for the communications functions to be performed. To emphasize this individuality of buildings, the criteria peculiar to the construction of the transmitter and receiver buildings and the communications center are set forth in chapters 3, 4 and 5. This chapter contains general building criteria applicable to all communications station buildings.

Although the primary objective of the design is to facilitate installation, maintenance and operation of the electronic equipment, other factors must be considered in determining the total floor area and the structural methods to be used. Administrative areas must be included, and personnel support requirements must be met. The possibility of earthquake, hurricane, and bomb damage must be considered in the structural design; however, the need for such survivability must not be permitted to degrade the primary mission of the structure which is to support communications.

The basic criteria governing the construction of communications buildings are contained in the following publications:

- NAVFAC DM-2 - Structural Engineering
- NAVDOCKS DM-3 - Mechanical Engineering
- NAVFAC DM-4 - Electrical Engineering
- NAVFAC DM-23 - Communications, Navigation Aids, and Airfield Lighting
- NAVELEX Inst. 011120.1, Shore Electronics Engineering Installation Guidance for for Equipments and Systems Processing Classified Matter

Related criteria concerned with construction is found in:

- NAVDOCKS DM-1 - Architecture
- NAVFAC DM-5 - Civil Engineering
- NAVDOCKS DM-7 - Soil Mechanics, Foundations, and Earth Structures
- NAVDOCKS P-89 - Engineering Weather Data

The structures are designed by NAVFAC. NAVFAC is guided by the specific requirements of the electronic installation which must be made known in the BESEP (see chapter 1). The following discussion presents general criteria that must be considered for applicability and effect upon the overall design of communications buildings both as to ultimate cost and effectiveness of communications.

7.2 BUILDING FEATURES

7.2.1 Ceilings

Suspended ceilings in the equipment and operational areas are preferred. It may be desirable to install in the false ceiling a unistrut grid system capable of supporting signal and power cable ducting or trays. The unistrut system would be on 4-foot centers and would be mounted flush with the suspended ceiling. A ceiling height of 10 feet is preferred.

7.2.2 Floors

Concrete flooring is satisfactory for communications buildings. Ground mats embedded within the flooring are required for transmitter buildings only. Raised flooring is authorized only on a special case basis and is usually reserved for computer installations. In the past, systems of cable ways, conduit, and "Q" cells have been embedded in concrete flooring, but such construction is no longer standard and is not recommended.

7.2.3 Cable Ways

Equipment cabling must be considered in building design. The preferred cable routing is through trays or ducts suspended from the overhead. When raised flooring is used, all cabling will be done within the space provided by the raised floor.

7.2.4 Fire Protection

Carbon dioxide and water fire fighting systems are required for communication buildings. Water sprinkler systems are authorized for installation within electronic spaces. In addition to other fire protection systems, fire hose stations having sufficient hose to reach everywhere in the space should be installed in or near the electronics space being protected.

Carbon dioxide hose reel systems may also be installed near the equipment being protected. Each CO_2 hose reel is to be supplied from a separate bank of high pressure cylinders, and the bank is to be designed for two separate actuations of 300 pounds of carbon dioxide. When an automatic carbon dioxide system is installed, the provision for personnel escape, and the necessity to warn personnel of the carbon dioxide hazard must be considered. The design of all carbon dioxide systems should conform to NFPA Standard No. 12.

7.2.5 Lighting

Working areas of the communication station buildings require from 40 to 50 foot-candles of light. Fluorescent lighting may be used in all buildings except transmitter helix houses. When fluorescent lighting is used in a receiver building the fixtures must be grounded with green, third wire of the power feeder and fitted with power line filters. Battery-powered floodlights are required for the emergency lighting of individual rooms and areas.

These battery-powered lighting systems are to be activated by relays in the normal lighting circuit.

7.2.6 Battery Room

A battery room or a vault, with provisions for ventilation, must be included in the design of each building.

7.3 ENVIRONMENTAL CONTROL

Control of the air temperature and humidity within communications building is required both for personnel and equipment. The anticipated heat dissipation of the electronics equipments as well as the limits for equipment ventilating air temperature and humidity must be stated in the BESEP.

Each electronic equipment should be carefully investigated as to its true requirement for ventilation before the BESEP writer specifies rigid temperature and humidity figures such as may be found in the equipment instruction book. A requirement for a specific amount of continuous ventilating air at a specific temperature may impose unnecessarily rigid restrictions on the building designer. Such an unqualified statement requires that the equipment must be supported by systems having 100 percent reliability and exact temperature control. A thorough investigation of the equipment may prove that operation is possible for a short period of time without ventilation or support from an outside system. On the other hand, if it is found that the equipment cannot operate without a support system the designer should be so informed. To design the best environmental system for the building, the designer should know the acceptable ranges for humidity, temperature and volume of ventilating air, along with any rate of change limitations.

Humidification is usually accomplished by introducing steam into the air stream. Facilities for steam are not usually planned for small stations or semi-transportable stations. Therefore, a requirement for humidity control at any of these locations should be carefully considered. The introduction of water vapor into the air stream for humidification purposes is not recommended because the water vapor is detrimental to the electronic equipment.

A designer may desire to include the equipment exhaust heat in his plan for controlling the overall building environment. In the cold climates exhaust heat may be used to heat a building; in tropical climates it may be more economical to cool the exhaust air for reuse rather than to dehumidify the outside air.

When the BESEP is prepared the requirement for an electronic equipment to exhaust ventilating air should not be translated to mean exhaust to the atmosphere, since all air exhausted to the atmosphere must be replaced. Individual equipment air exhaust or supply systems are expensive, seldom practical and difficult to maintain. Ducting of ventilating air to and from equipment should be specified on a special case basis only.

The preferred method of providing ventilating air to a space is through ducts along the overhead or through ducts above the suspended ceiling. The ventilating air should be expelled and exhausted through ducts that lead directly into the space that is ventilated. Systems that require air to be distributed through perforated ceilings or by the void space under a raised floor are not recommended.

When the degree of reliability is specified for an environmental system, a reliability percentage figure without qualifying factors should be avoided. In lieu of a stated percentage figure, the permissible total system down time could be specified thereby allowing the designer to provide a system that would permit short interruptions of service such as might occur when a drive belt requires replacement. Another possibility would be to designate as critical a portion of the system. This may allow the designer to split the environmental control requirement among several units so that one unit would always be available for the critical load. Alternatively, one additional unit could be provided for reliability assurance.

CHAPTER 8

STATION ELECTRICAL POWER

8.1 GENERAL

Power requirements for technical equipment are to be furnished in the BESEP (chapter 1) for use by the electrical power design agency, NAVFAC. Power sources and system distribution are planned and designed by NAVFAC guided by the requirements of the BESEP. Although the station power may be supplied by a combination of the types shown in table 8-1, primary power is usually supplied by a commercial power company. The design of the power distribution system within the station is accomplished by grouping equipments into load categories and feeding each load category from a separate bus. The general types of load categories are shown in figure 8-1. The decision to select a commercial company to supply the station power is based upon an investigation of the company's ability to meet the requirement. Factors for determining the adequacy of a commercial power company are contained in NAVFAC DM-4 — "Electrical Engineering."

Power requirements peculiar to each portion of the communication station are contained in chapters 3, 4 and 5. General requirements and factors to be considered for power requirements stated in the BESEP are discussed below.

8.2 DEMAND LOAD

The demand load for electronic equipments is 100% of the technical load.

8.3 POWER REGULATION

The need to specify power regulation beyond normal commercial standards should be carefully evaluated. When a high degree of power regulation is required it must be carefully defined and its use must be strictly limited to the purpose intended.

8.4 NO-BREAK POWER

No-break power (Class D) is provided on a case basis. The synchronous equipment found in the communications center building is usually the only equipment supplied from a Class D power source.

8.5 EMERGENCY POWER

Emergency power (Class C) systems are used to enable rapid restoration of power to the technical load. Class C power is usually required for each separate communications facility.

Table 8-1. Station Power Sources

CLASS	TYPE	SERVICE	DISTRIBUTION LOAD	LOAD CAPACITY	LOCATION	PRIME MOVER	SPARES	FUEL STORAGE	START AND CONTROL
Off Station	Primary	Preferred total station power supply	Separated buses	125% of station demand load	Off station	-	Alternate service route	-	Synchronous control for switching to and from station power.
A	On Station Primary	Provides total station power requirement when off station power not acceptable	Separated buses	125% of station demand load	Within station boundary. 5 mi from receivers 1500 ft from comm. bldgs.	Low speed diesel 450-900 RPM	2 units, one for maintenance, one for standby.	Continuous supply with 30 days on hand	Synchronous control for switching between station and class B power.
B	Auxiliary	Provides standby power to cover extended (days) outage of primary power	Separated buses	125% of demand load to which connected	Near primary substation. Adequate noise and vibration isolation.	Low speed diesel 450-900 RPM	1 unit, in standby or maintenance.	15 days refillable	Automatic starting at primary power variation of ±10% of design voltage or ±3. 33% of design frequency for 5 seconds.
C	Auxiliary	Provides power on a quick start basis (10-60 sec) to cover short term outages (hrs) of primary power	1 bus up to 300 kW 120/208 volts. 1 bus up to 600 kW 277/480 volts.	125% of technical load	Adjacent to or within bldg served. Collocated with Class D.	High speed diesel 900-1800 RPM vibration isolation mounting	Not required. May provide 1 unit for maintenance.	7 days refillable	Automatic starting under same conditions as Class B above. When capable of supplying critical technical load a means to synchronize between Class D and C units is required.
D	Primary critical technical load	Provides uninterruptible (no-break) power within specified voltage and frequency tolerance	1 bus at voltage of station critical technical load.	125% of critical technical load	Same as Class C	High speed diesel 900-1800 RPM vibration isolation mounting	One unit in standby or maintenance. Emergency backup from station primary power.	-	Automatic synchronizing between standby and inservice unit. Automatic sensing of primary power and automatic power and automatic shifting to and from primary station power.

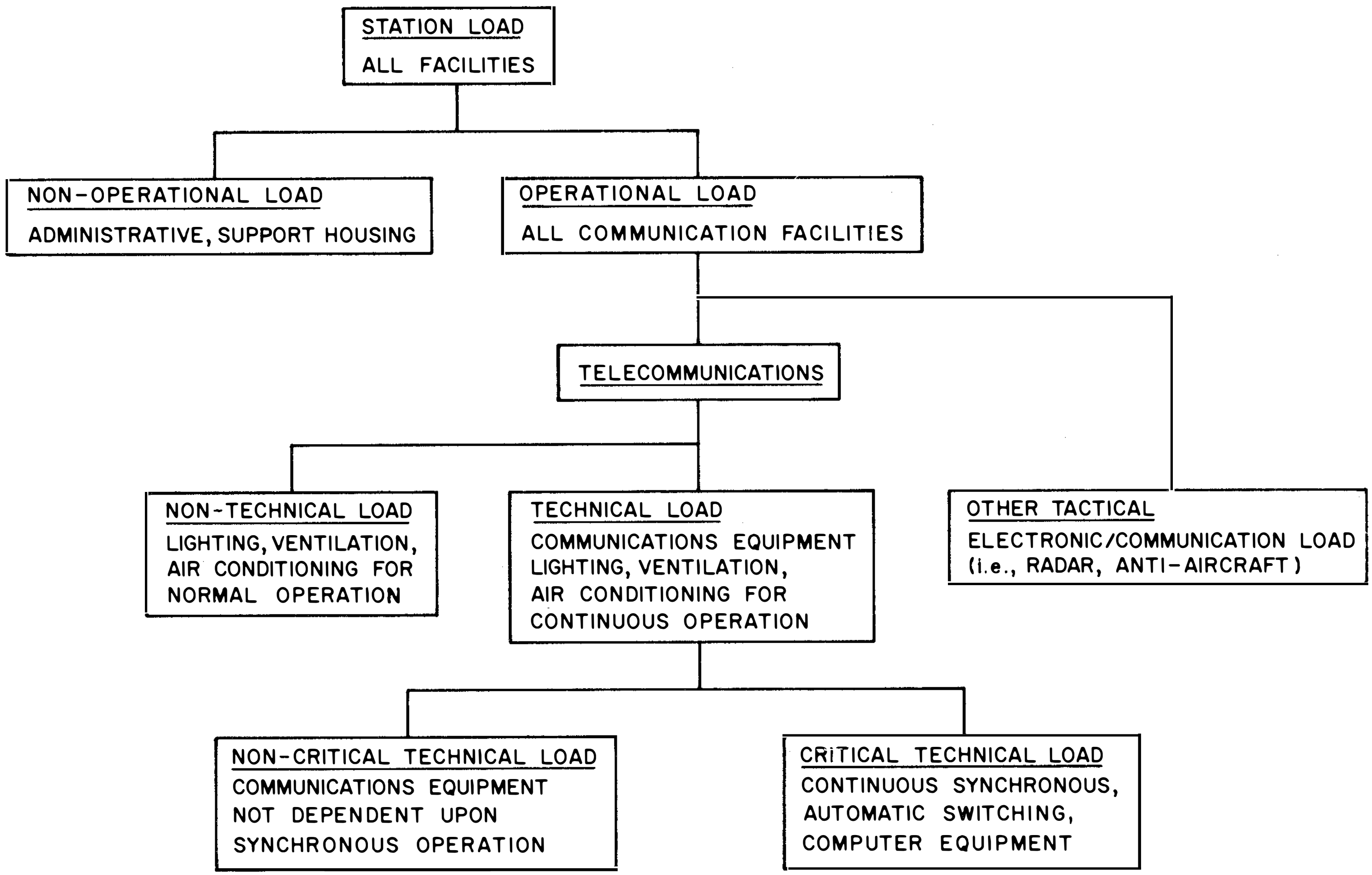


Figure 8-1. Electrical Load Categories

8.6 POWER CONDITIONING FOR SECURE COMMUNICATIONS

Power used to supply equipments that process Red information may require special conditioning to ensure communications security. NAVELEX Instruction 011120.1 is the controlling document governing power conditioning, and it specifies the conditions under which power feeders are to be enclosed within ferrous shielding. The BESEP should specify ferrous shielding for power feeders and special conditioning of power only as required by the effective edition of NAVELEX Instruction 011120.1.

CHAPTER 9

PATCHBOARDS AND DISTRIBUTION FRAMES

9.1 GENERAL

Patchboards and distribution frames are standardized at shore stations through the application of the standard plans issued by NAVELEX. These plans designate the type of frame and patchboard required to satisfy each segment of a circuit as it is distributed throughout the communications station. Distribution frames serve as the point of termination for signal and control cabling within the building and for cabling leading to and from the building. Interconnections between the cables are accomplished by "cross-connect" wires that are run between the individual wire terminations of the cables at the frames. The patchboards serve as the access point for operators to monitor the signal carried by individual cable wire pairs and permit operators to reroute circuits and to substitute equipment serving a circuit. Types of equipment, standard terminology, and specific wiring practices for patchboards and distribution frames are discussed below.

9.2 PATCHBOARDS

NAVELEX standard plans detail the construction features of the standard circuit patchboard. The four basic patchboard types are:

a. Audio Patch Module, NAVELEX Standard Plan RW 10F2069C.

b. DC Patch Module, NAVELEX Standard Plan RW 10F2383A.

c. General Purpose Multi-Circuit Patch Module, NAVELEX Standard Plan 0100305.

d. KWX-8 Remote Functional Patch, NAVELEX Standard Plan RW 10F2399.

Figures 9-1 and 9-2 depict the standard jack configuration for audio and DC patchboards. These patchboards are packaged as modules containing 26 jack groups that may be used for send or receive circuits. Modular packaging permits acquisition of patchboard equipment only as necessary to meet the existing circuit requirements and makes possible the addition of patchboards as the need arises. The following criteria govern the use of patchboard equipment:

a. A maximum of four modules may be installed in one cabinet.

b. Patchboard modules are to be installed in the upper portion of the cabinet to facilitate use by an operator in a standing position.

c. The lower portion of a patchboard cabinet may be used for battery supplies or other equipment, such as fuse panels and hubbing units, that require little or no operator attention.

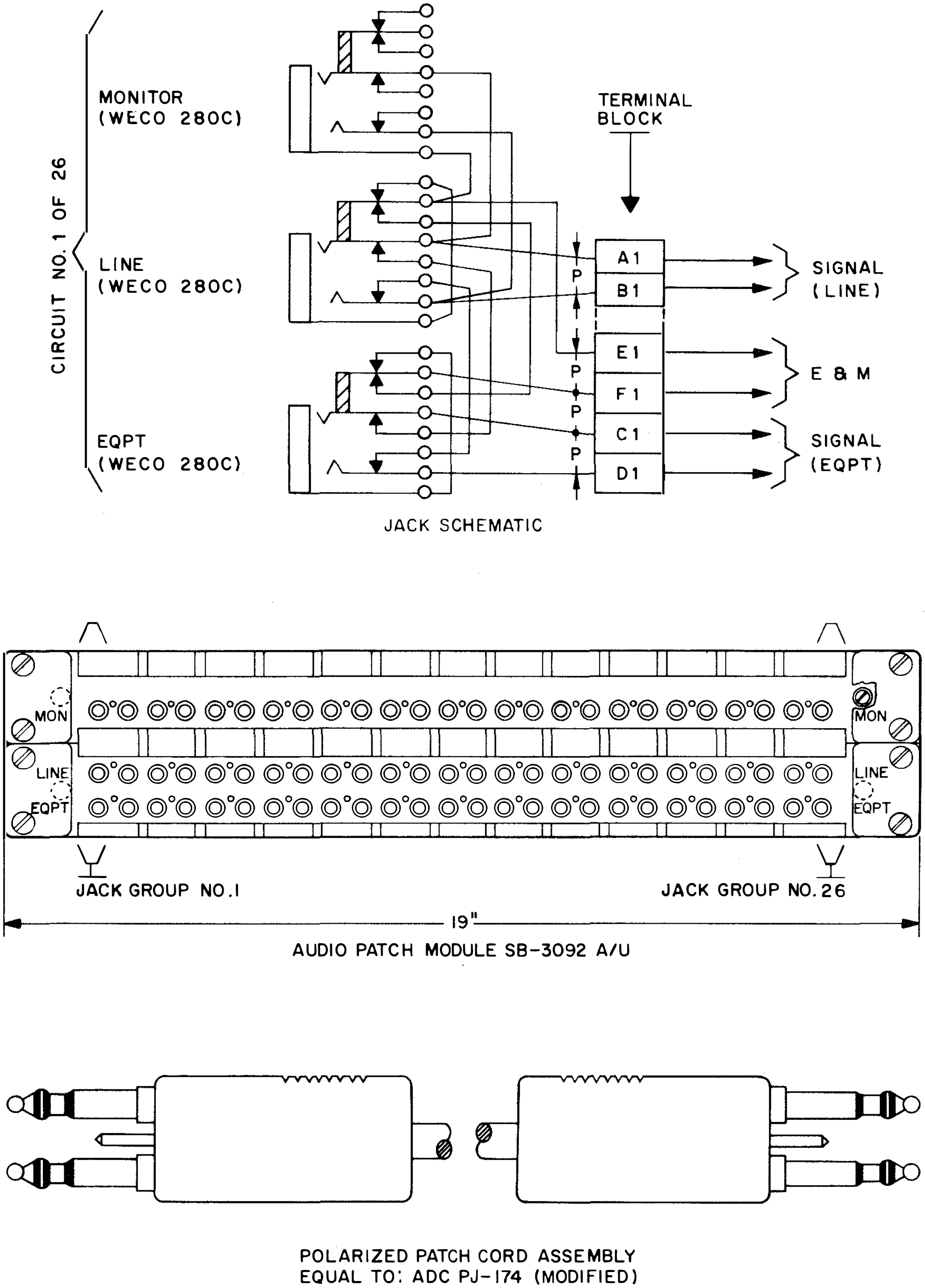
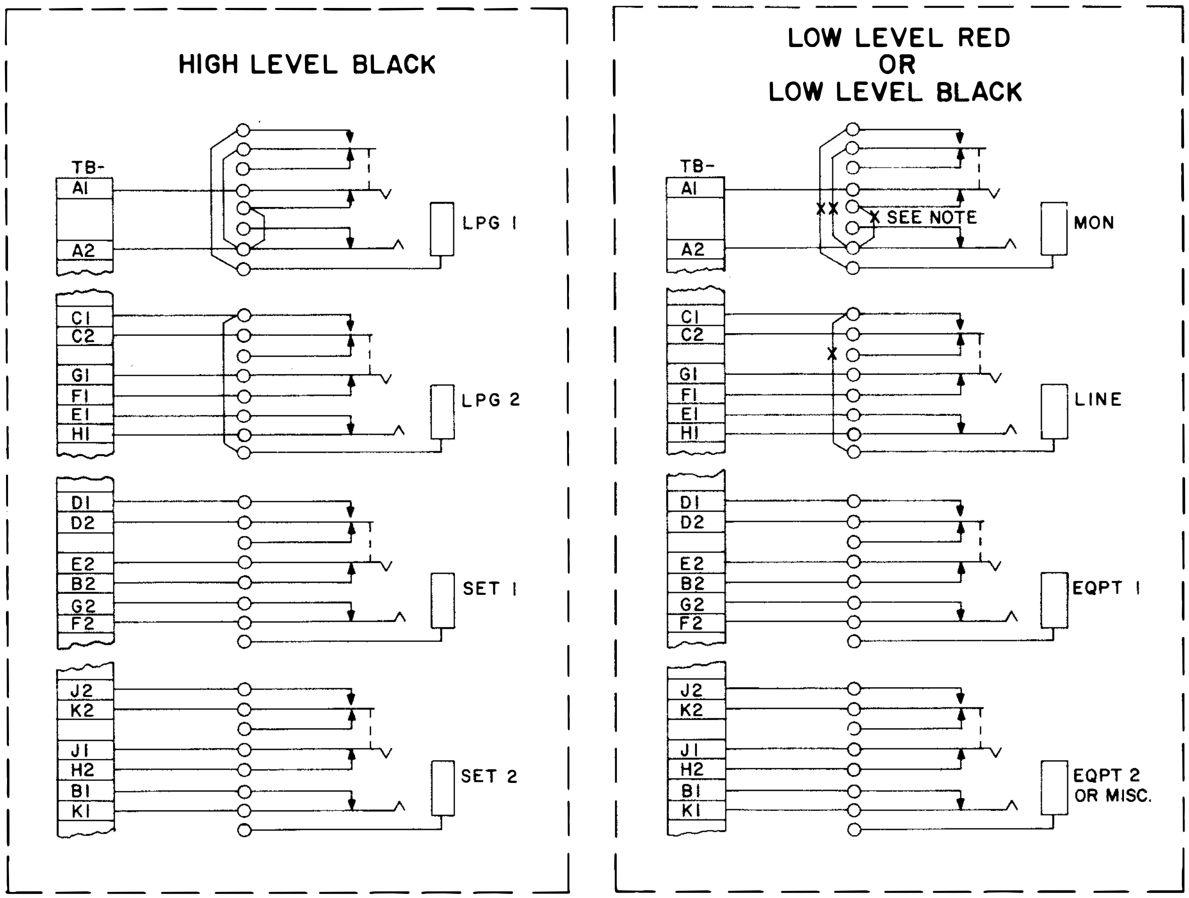
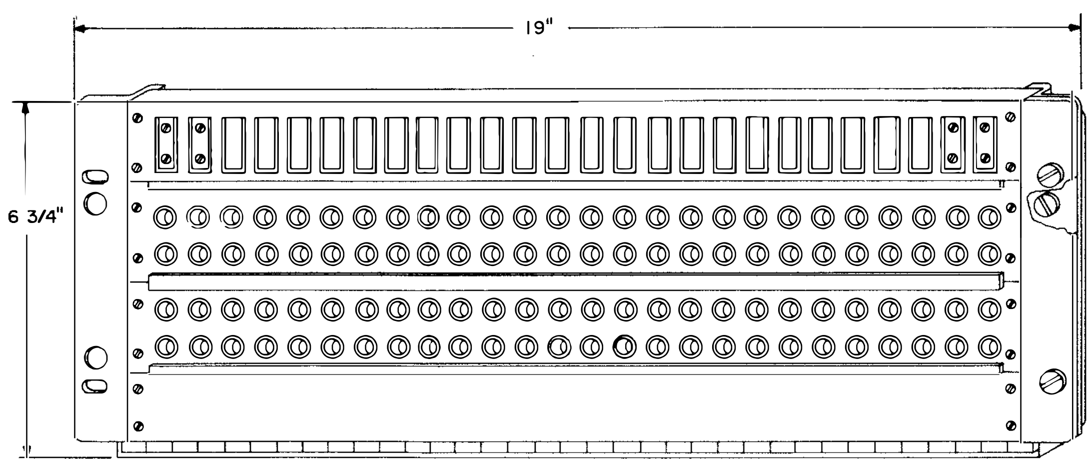


Figure 9-1. Basic Audio Patchboard Module, SB-3092/AU



JACK SCHEMATIC



FRONT VIEW PATCH MODULE

NOTE:
PATCH MODULES ARE MANUFACTURED FOR USE IN A HIGH LEVEL ENVIRONMENT. THE STRAPS ON THE TWO TOP JACKS MUST BE CUT FOR LOW LEVEL USE.

Figure 9-2. Basic DC Patchboard Module, SB-3189A/FGC

9.3 DISTRIBUTION FRAMES

The communications station employs distribution frames for concentrating individual circuits into cables; these frames serve as the point of equipment interconnection and as the interface point between the outside world and the circuit distribution within the building. Four types of distribution frames may be used within a communications station.

a. Main Distribution Frame (MDF)

b. Intermediate Distribution Frame (IDF)

c. Classified Intermediate Distribution Frame (CIDF)

d. Combined Distribution Frame (CDF)

Distribution frames are built up of terminal blocks composed of rows of terminals. Each terminal extends through the block so that individual wires of a cable will be terminated on one side of the block and cross-connect wires will be terminated on the opposite side of the block. Frames must be planned so that sufficient room within the frames is available to permit the addition of blocks to support any known expansion requirement.

All blocks used to terminate internal cabling are to be positioned vertically within a frame. Horizontal blocks are to be used only to terminate cables leaving the building or interfacing with a system that supports intersite communications such as the microwave system.

Wire termination methods contained in MIL-STD-1130 are approved for distribution frame installation. The wire-wrap method is approved for permanent connections only and may not be used on the cross-connect side of a terminal block. All other terminations on these frames are to be the solder or push-on type. The following types of terminal blocks are approved for use in a distribution frame:

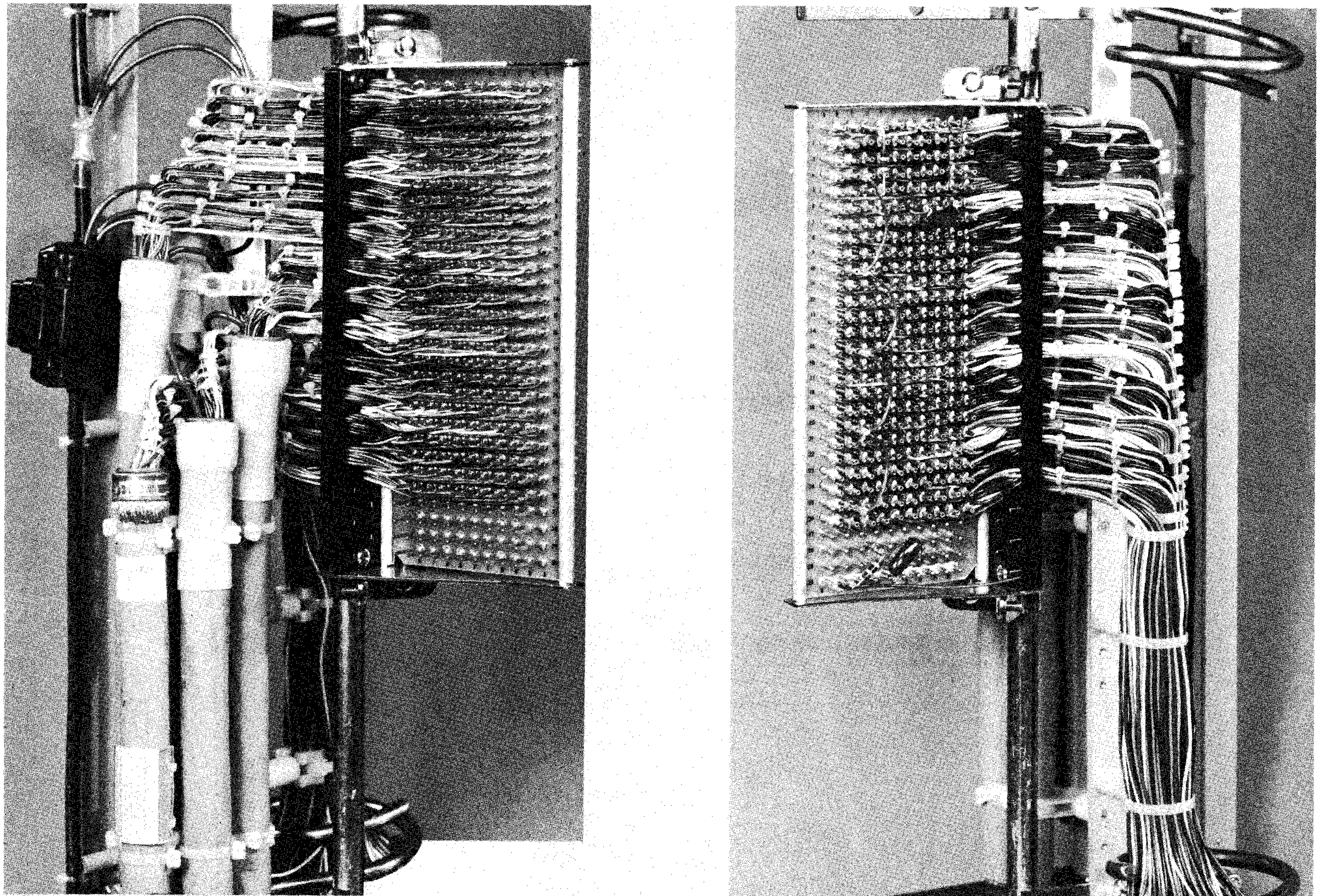
a. Solder-to-solder connections.

b. Wire-wrap to push-on.

Wire-wrap to wire-wrap, wire-wrap to solder, and taper pin terminal blocks are not to be used. A wire-wrap to push-on terminal block is shown in figure 9-3.

9.3.1 Main Distribution Frame

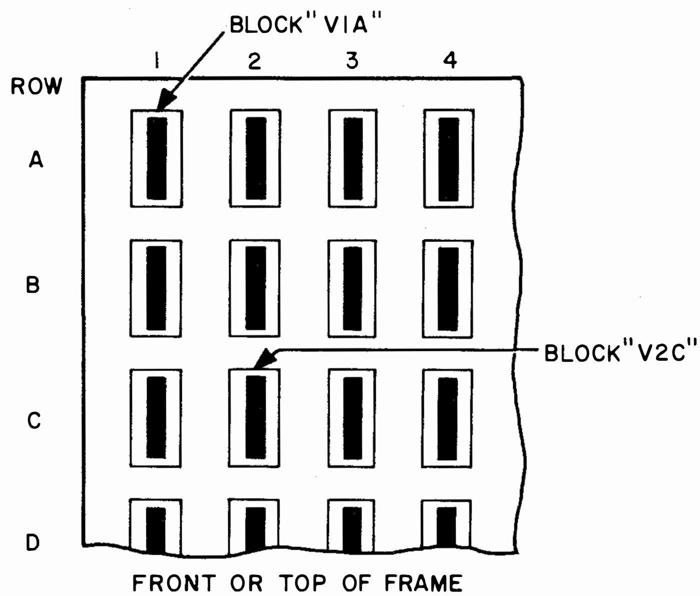
The MDF is to be built up of horizontal and vertical terminal blocks as illustrated in figure 9-4. The horizontal blocks terminate circuit cables entering the building through fused terminals. These fused terminals protect inside equipment against excessive external circuit currents. The horizontal blocks of this frame are also used to terminate the cabling from the intersite link facilities. Vertical blocks are used to terminate cables that support internal circuit distribution of the building. The MDF is usually located above the external cable entry point, and the external cables are fed up to the frame for individual wire termination. Distribution to locations in the building is accomplished by connecting internal distribution cables to the vertical blocks of the MDF and leading the internal cable up to overhead ducts or trays. All



CABLE TERMINATION SIDE

CROSS-CONNECT SIDE

Figure 9-3. Wire Wrap to Push-On Terminal Block



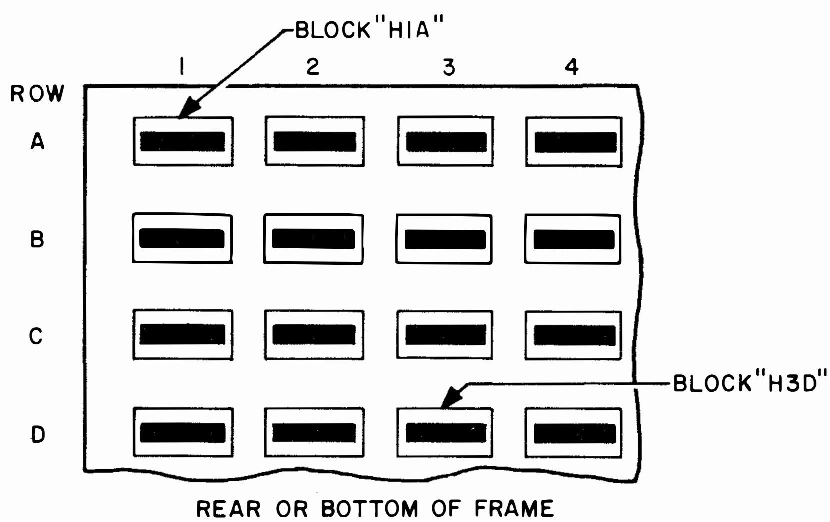


Figure 9-4. MDF/CFD Block Configuration and Designation

cabling is run on the inner portions of the frame, and the individual wires are brought out through the fanning strips of the terminal blocks to the wire termination. The cables are secured to the inner portions of the steel frame to prevent any stress on the wire terminations. Figure 9-5 depicts a typical MDF.

9.3.2 IDF and CIDF

The IDF terminates internal distribution cables, equipments, and patchboards that process Black information. The CIDF terminates cables, equipments, and patchboards that process Red information. The IDF should be physically separated from the CIDF by a minimum of two inches; however, it is desirable to locate these units on opposite sides of the room.

These IDF and CIDF frames are composed of rows of terminal blocks mounted in a vertical position. The blocks and the method of laying cable into the blocks are standardized by NAVELEX Standard Plan RW 10F2101. Figure 9-6 shows the solder-to-solder type terminal blocks and wiring plans. The individual cable wires are laid into the block in sequence according to the wire color code for each individual cable. Shields for individual pairs are provided on a special case basis. When shielded pairs are used, the shields are terminated at the intermediate distribution frame in the manner shown in the wiring plan of figure 9-6.

The cabling to the blocks is brought to the inner portion of a frame with front and back blocks and to the rear of frames with a front block arrangement only. The cabling runs to the frame from the overhead or from the bottom according to the cable distribution system used in the building. In either case the cable is tied to the frame for support to prevent any stress on the wire termination. Typical intermediate distribution frames are shown in figure 9-7.

It is sometimes expedient and practical to route one or more multi-conductor cables from the CIDF or IDF to an equipment room and then connect the multi-conductor cables to smaller cables to form branches leading to the individual equipments. When this is practiced, a "junction box" is used to terminate the cable within the equipment room. The junction box is composed of terminal blocks similar to those used in a distribution frame. This similarity may result in the junction box being mistaken for a distribution frame. However, the junction box can be readily distinguished from a distribution frame by the absence of cross-connect wiring. In a junction box, the smaller cables are connected directly to the back of the terminal block on the terminal corresponding to the front termination of the larger cable. In a distribution frame, cables are interconnected through cross-connect wiring.

9.3.3 CDF

A CDF may be used at small stations, serving the purpose of both the IDF and MDF. When a CDF is used, the blocks that terminate cables and systems that interface with the outside world are to be positioned horizontally. Blocks used to terminate cables supporting internal distribution are to be positioned vertically.

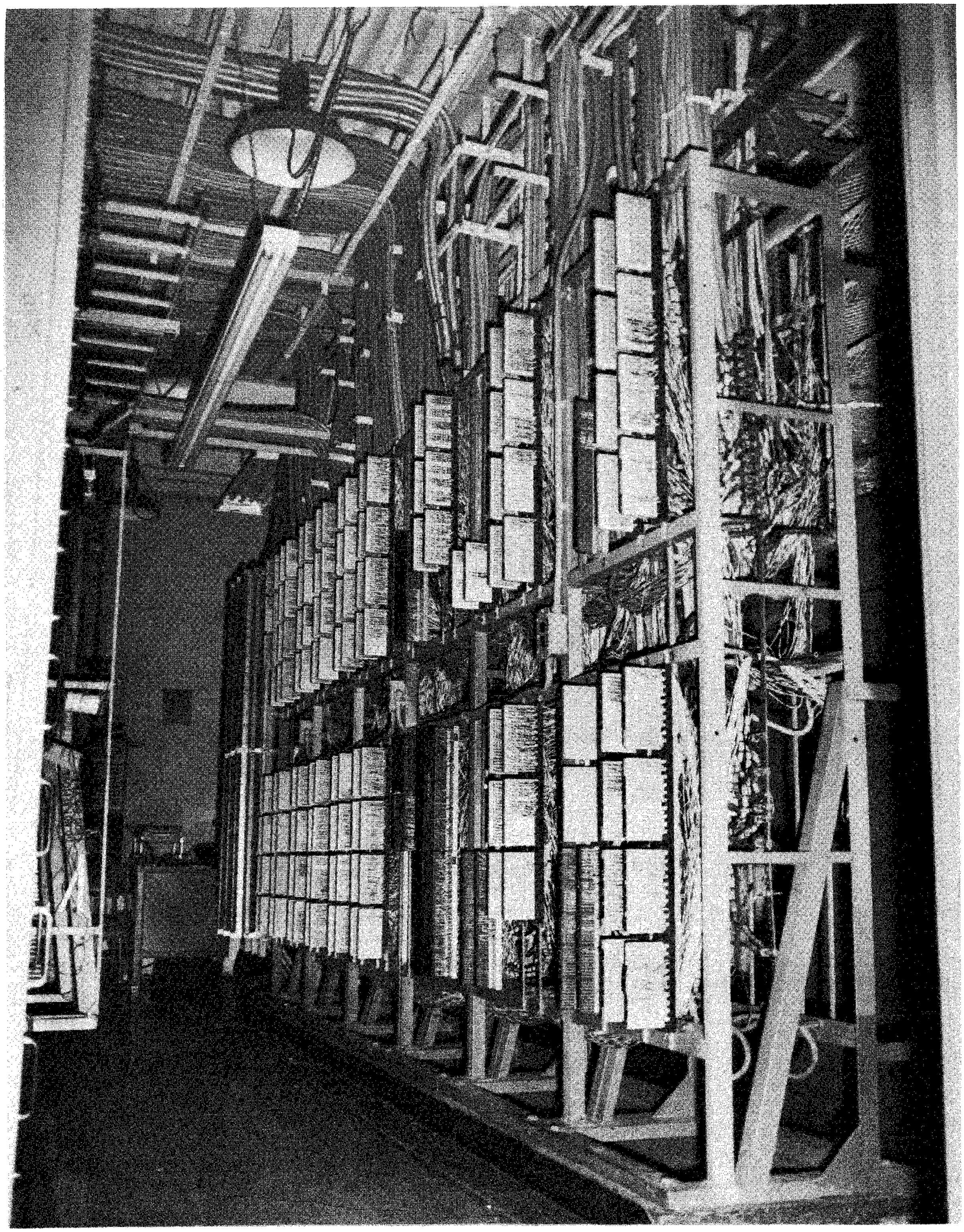


Figure 9-5. Typical Main Distribution Frame

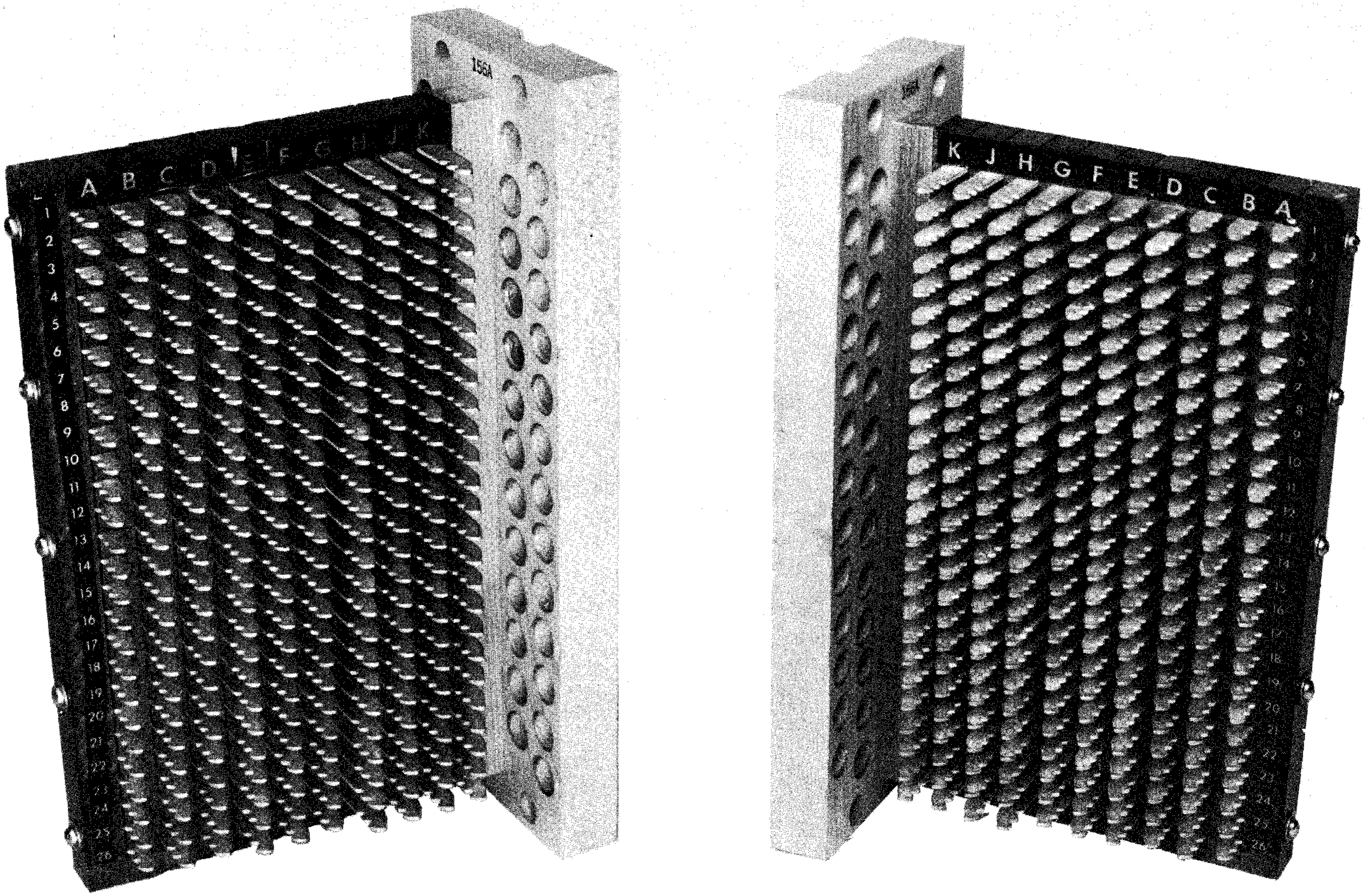


Figure 9-6. Intermediate Distribution Frame Terminal Blocks (Sheet 1 of 4)

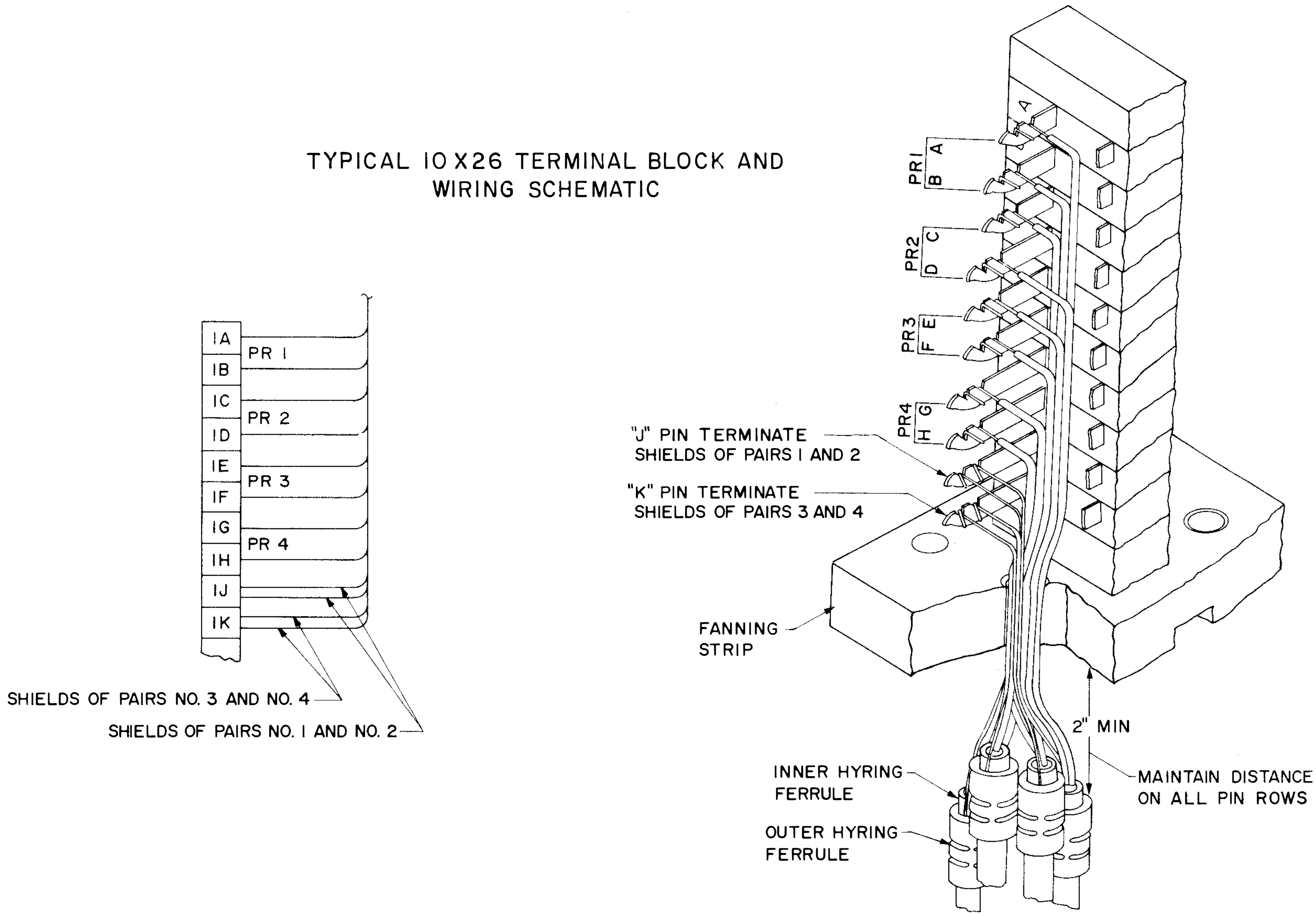


Figure 9-6. Intermediate Distribution Frame Terminal Blocks (Sheet 2 of 4)

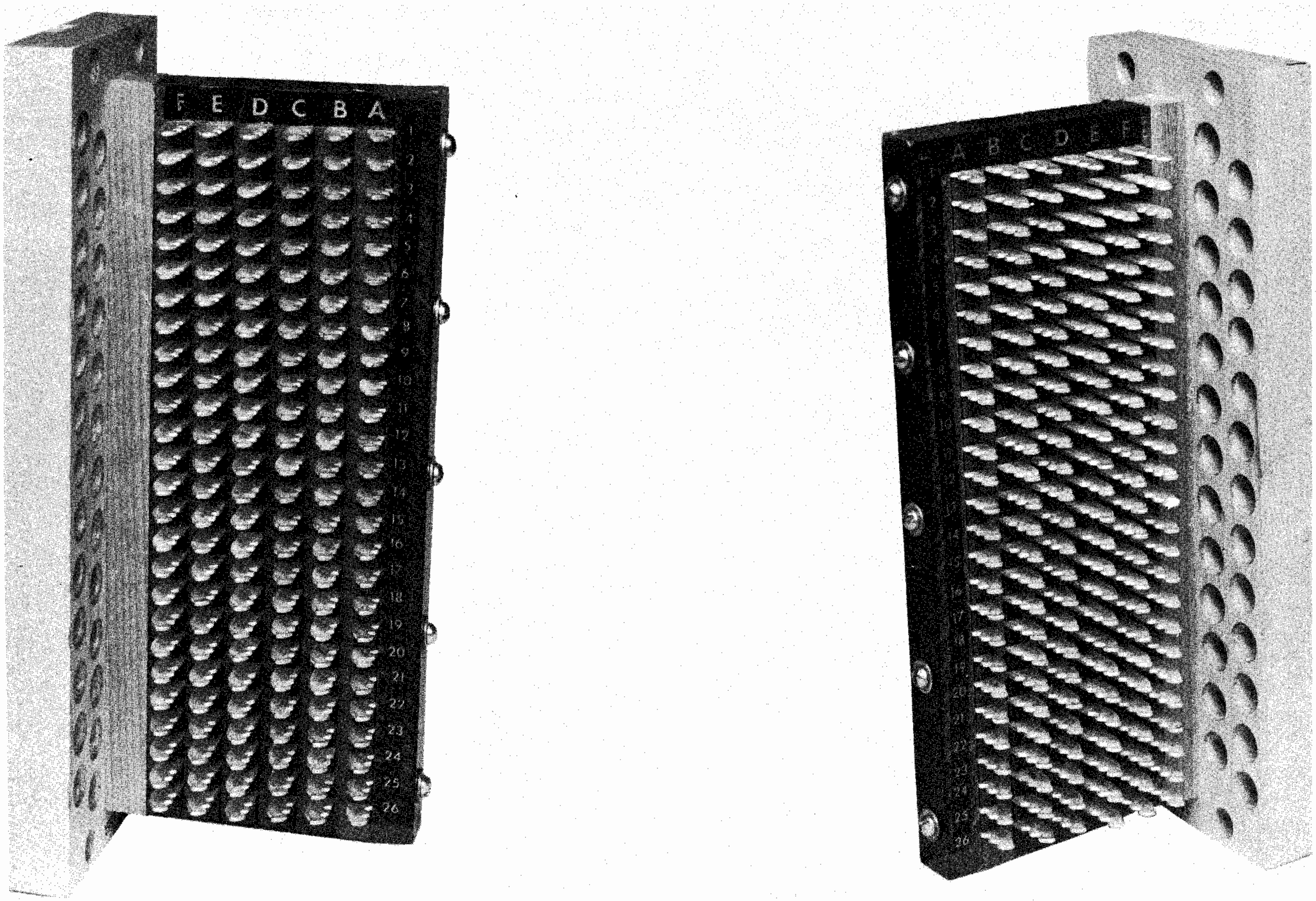


Figure 9-6. Intermediate Distribution Frame Terminal Blocks (Sheet 3 of 4)

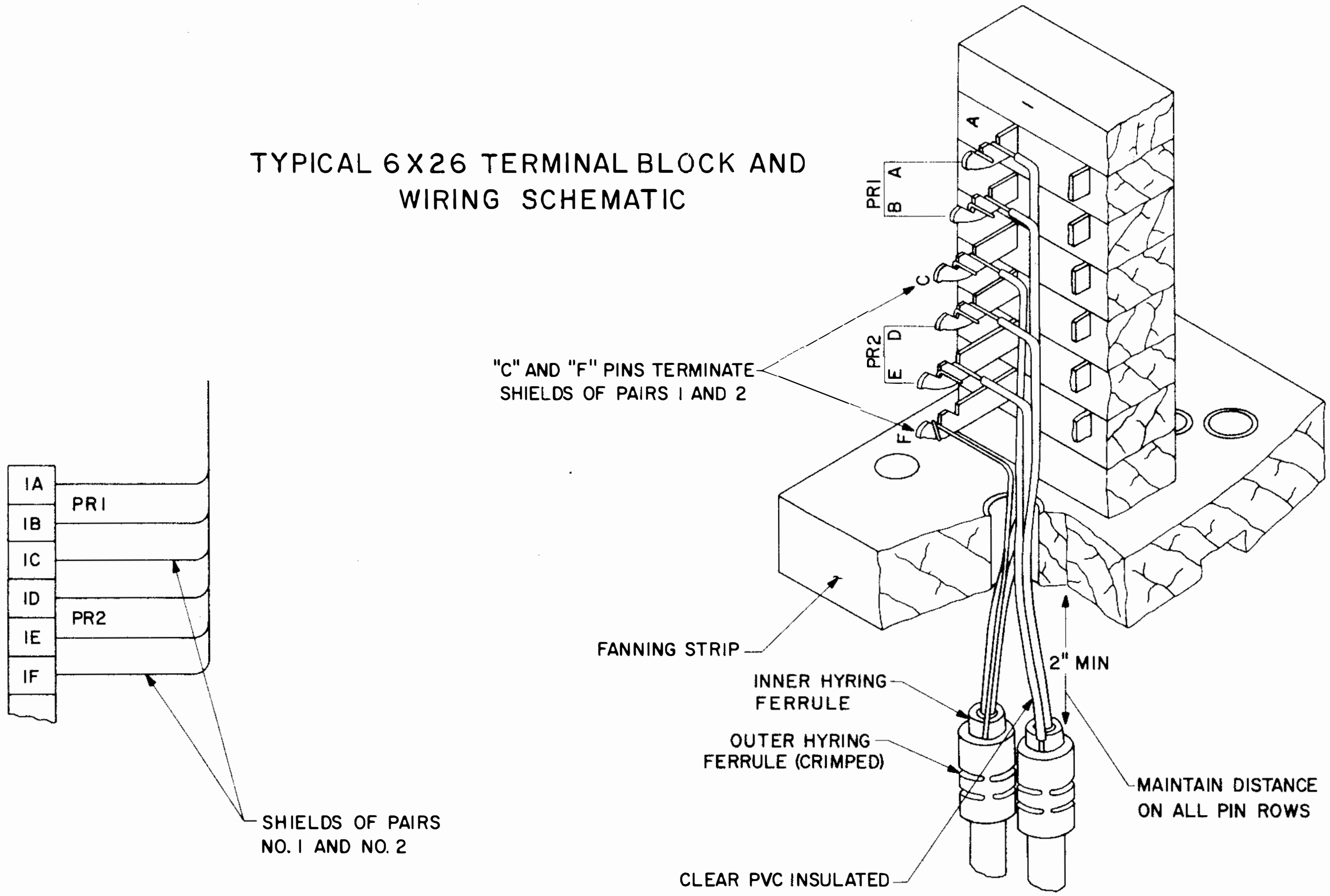
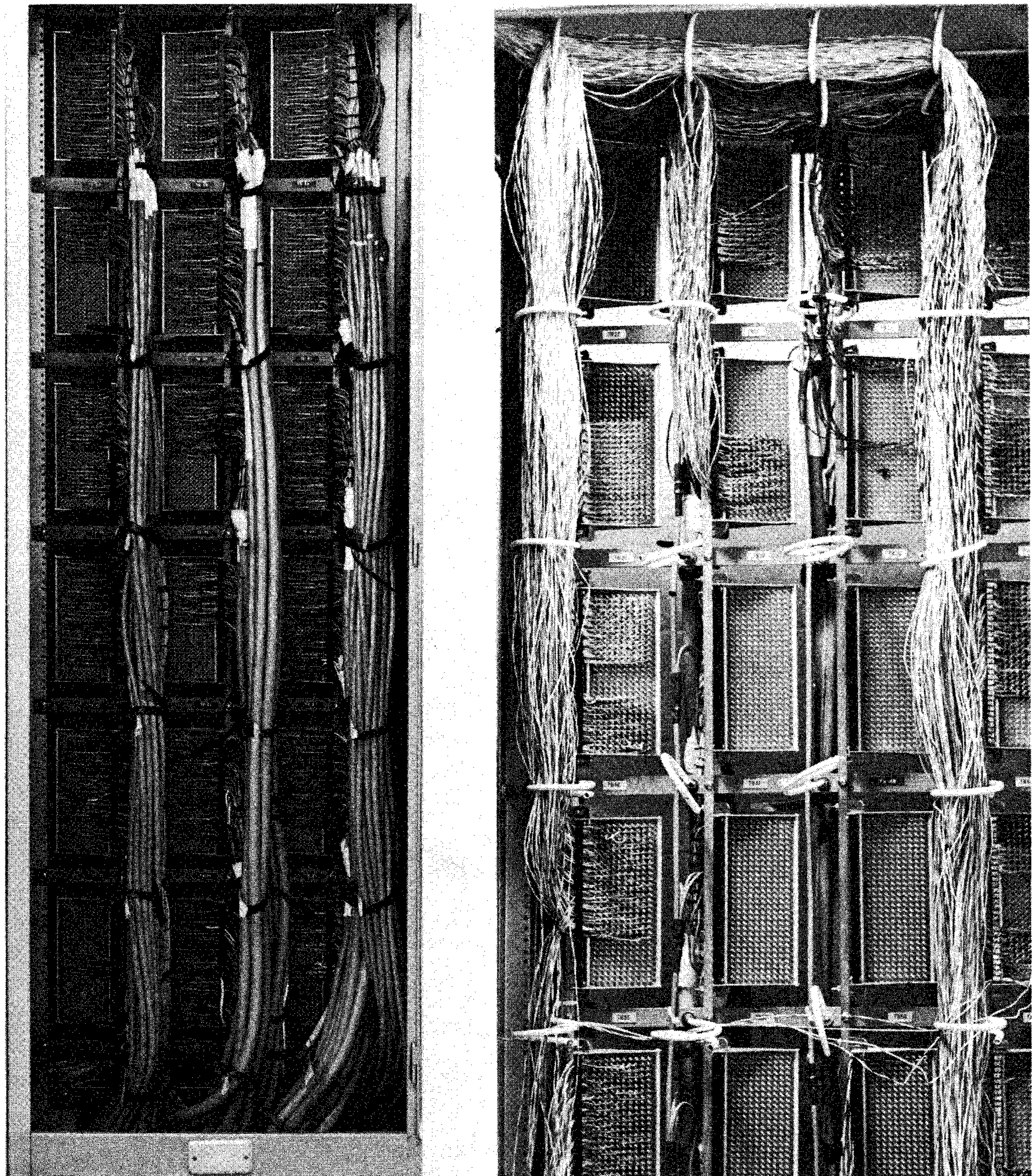


Figure 9-6. Intermediate Distribution Frame Terminal Blocks (Sheet 4 of 4)



CABLE TERMINATION SIDE CROSS-CONNECT SIDE

Figure 9-7. Typical Intermediate Distribution Frames

9.4 CROSS-CONNECTS

Cross-connects are wires that interconnect terminals of the distribution frame terminal blocks. These wires may interconnect terminals on the same block or may run from one block to another. Of the types of termination authorized for cross-connects (paragraph 9.3), solder type termination is the one most often used.

Cross-connects are made of wire designed especially for distribution frame use. To facilitate wiring this cross-connect wire is color coded and is available in singles, pairs, triplets and quads. Western Electric Company Type V is commonly used as the cross-connect for a distribution frame.

The cross-connect wires should be run in a manner that presents a neat uniform pattern such as shown in the examples of figure 9-8. Each cross-connect should be run loosely to insure adequate length and to facilitate relocation or removal as required. In general, any practice that will cause the cross-connect wire to tangle, or otherwise become caught on lugs or other objects, should be avoided. When twisted pair, triplet or quad cross-connect wire is used, the conductors should be untwisted at each end so that each conductor enters the terminal block fanning strip individually. However, the wire should not be untwisted more than one regular twist back of the fanning strip. A color code compatible with Red or Black, high or low level operation has been established for single conductor cross connect-wire as shown in table 9-1.

Table 9-1. Cross-Connect Color Code

DC SEND LINE	GREEN
DC SEND LINE RETURN	GREEN/WHITE
DC RECEIVE LINE	ORANGE
DC RECEIVE LINE RETURN	ORANGE/WHITE
VOICE FREQUENCY SEND LINE	BLUE
VOICE FREQUENCY SEND LINE RETURN	BLUE/WHITE
VOICE FREQUENCY RECEIVE LINE	BROWN
VOICE FREQUENCY RECEIVE LINE RETURN	BROWN/WHITE
SEND CONTROL	GRAY
RECEIVE CONTROL	VIOLET
+6V BATTERY	RED
–6V BATTERY	BLACK
GROUND	WHITE
ALARM	YELLOW

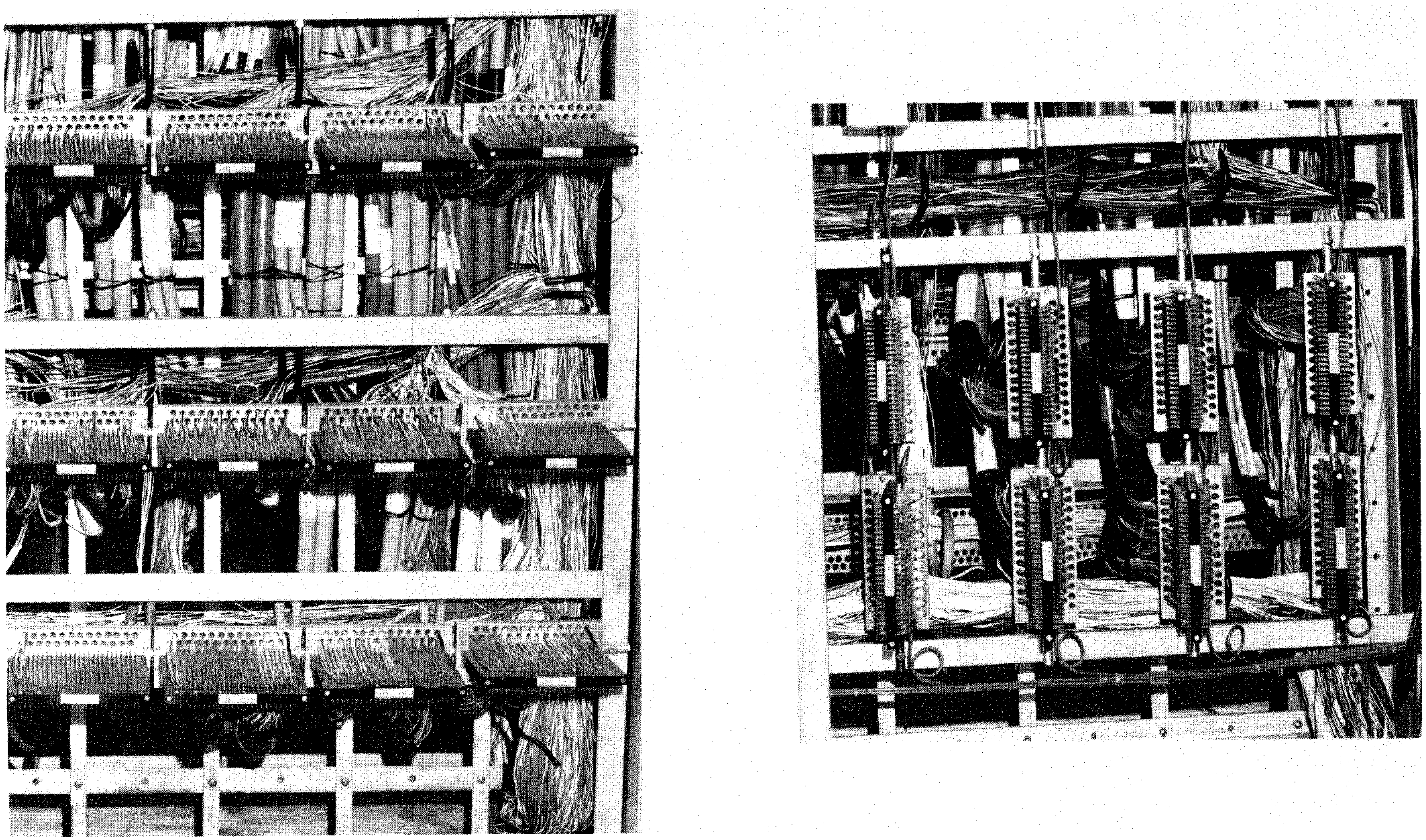


Figure 9-8. Distribution Frame Cross-Connects

10.4 EQUIPMENT STANDARDS

The DCS standards prescribe individual equipment standards as necessary to (1) standardize the type of interface between equipment and (2) establish independent sideband operation and a nominal 3-kHz bandwidth channel as the standard for communications using HF radio transmission system. Figures 10-2 and 10-3 show the required frequency response of the standard HF radio transmission system. Tables 10-6 through 10-10 summarize (1) the performance criteria for transmitters, receivers, and wideband multiplex equipment, and (2) the quality and bandwidth limitations for the HF radio circuit.

10.5 QUALITY CONTROL

An effective method of quality control (QC) is essential for maintaining the worldwide services required by the users of DCS. The policies of and procedures for QC within DCS are established in DCAC 310-70-1 — "DCS Technical Control Procedures," Volume II, dated January 1967. The QC schedule for DCS circuits and the tests required are listed in table 10-11.

10.6 CONVERSION FACTORS AND DEFINITIONS

Table 10-12 and figure 10-5 may be used for conversion of various units of noise power measurement. Table 10-13 defines the terms appearing in this chapter.

Table 10-1. Voice-Transmission Criteria 4-kHz Circuit

CHARACTERISTIC	OBJECTIVE		STANDARD	
	Hz	dB	Hz	dB
Net Amplitude Attenuation referenced to 1000-Hz test tone *	300 400 600 2400 3000 3400	+30 to –6 +7 to –6 +2 to –2 +2 to –2 +8 to –6 +30 to –6	300 - 3400 400 - 3000 600 - 2400	+30 to –12 +15 to –10 +6 to – 6
Receive Levels	 Maximum Average Minimum	vu –21.5 –28.0 –33.5	 Maximum Average Minimum	vu –22.9 –28.8 –34.7
Total Circuit Noise	30 dBrnc		39 dBrnc	
Single Tone Noise Limit	22 dBrnc		30 dBrnc	
Cross Talk **	55 dB below signal level		55 dB below signal level	
Echo	Echo suppression required at two-wire to four-wire connection points			

*An attenuation increase between input and output is indicated by (+). An attenuation decrease between input and output is indicated by (–).

**Measured between any two 4-kHz channels of a single system.

Table 10-2. Digital Transmission Criteria

	LOW SPEED DATA (300 BAUD OR LESS) USER TO USER	DATA GRADE CIRCUIT (2400 BAUD OR LESS) SUBSCRIBERS ACCESS LINES		DATA GRADE CIRCUIT (2400 BAUD OR LESS) NETWORK SWITCH TO NETWORK SWITCH		DATA GRADE CIRCUIT (2400 BAUD OR LESS) USER TO USER OR USER TO REGENERATIVE REPEATER	
	OBJECTIVE	OBJECTIVE	STANDARD	OBJECTIVE	STANDARD	OBJECTIVE	STANDARD
NET AMPLITUDE ATTENUATION referenced to 1000 Hz test tone. *							
300 to 3000 Hz		-1.0 to +3.0 dB		-0.7 to +2.0 dB		-2.0 to +6.0 dB	
500 to 2800 Hz		-1.0 to +1.5 dB		-0.7 to +1.0 dB		-2.0 to +3.0 dB	
DELAY DISTORTION LIMITS							
500 Hz		500 μsec	500 μsec	500 μsec	500 μsec	3000 μsec	3000 μsec
600 Hz	4280 μsec	250 μsec	250 μsec	250 μsec	260 μsec	1500 μsec	1550 μsec
800 Hz	4280 μsec	125 μsec	230 μsec	125 μsec	260 μsec	750 μsec	1550 μsec
1000 Hz	2910 μsec	50 μsec	90 μsec	50 μsec	80 μsec	300 μsec	500 μsec
2600 Hz	2910 μsec	50 μsec	90 μsec	50 μsec	260 μsec	300 μsec	1250 μsec
2800 Hz	4280 μsec	125 μsec	230 μsec	125 μsec	500 μsec	750 μsec	2500 μsec
3000 Hz	4280 μsec	250 μsec		250 μsec		1500 μsec	
TRANSMISSION VARIATIONS							
Standard deviation		1.2 dB	1.6 dB	1.0 dB		2.6 dB	3.0 dB
Bias		±0.5 dB	±0.5 dB	+0.5 dB		±1.2 dB	±1.2 dB
NOISE LIMIT		26 dBrnc at users equipment		38 dBrnc	42 dBrnc	36.4 dBrnc at users equipment	40.2 dBrnc at users equipment
NOISE, Impulse counts per thirty minute period limit		90 at 58 dBrn		90 at 63 dBrn	90 at 68 dBrn	90 at 63 dBrn	90 at 68 dBrn
AMPLITUDE HIT LIMIT	±4 dB	±2 dB	±4 dB	±2 dB	±4 dB	±2 dB	±4 dB
PHASE HIT LIMIT	35°	30°	35°	30°	35°	30°	35°
SINGLE FREQUENCY INTERFERENCE LIMIT		22 dBrnc at users equipment		30 dBrnc	38 dBrnc	22 dBrnc at users equipment	
FREQUENCY DISPLACEMENT	±2 Hz	±2 Hz		±2 Hz		±2 Hz	

* An attenuation increase between input and output is indicated with a (+). An attenuation decrease between input and output is indicated with a (-).

Table 10-3. DCS Circuit Parameter Codes

SERVICE	NARRATIVE DESCRIPTION OF DCS SERVICE	CIRCUIT PARAMETER CODE
USER-TO-USER CIRCUITS:		
Voice	Nonsecure voice circuit. (Secure voice included under telegraph and data service.)	V1
Facsimile	Includes facsimile transmission which can be accommodated over a voice grade channel with no special conditioning. If the required facsimile (including telephoto) service involves special conditioning of the voice channel, the specific circuit parameters will be developed based upon the characteristics of the equipment to be used in the circuit.	V1
Telegraph and Data	Less than 46 baud. Includes 60-wpm teletypewriter and other DC keying service below 46 baud.	N1
	46 through 75 baud. Includes 75-wpm and 100-wpm teletypewriter service and other DC keying service from 46 through 75 baud.	N2
	76 through 150 baud. Includes 110-baud teletypewriter and other DC keying service from 76 through 150 baud.	N3
	300 through 600 baud. Includes data transmission and other service operating at 300 through 600 baud.	D2
	066-068 IBM (10 to 40 cpm).	V1
	1200 baud. Includes data card transmission and other service operating at 1200 baud.	D2
	2400 baud. Includes all types of alternate voice and data service including secure voice operating at 2400 baud.	S1
	2400 baud. Limited to data service only.	D1
	50,000 bits/sec (within 50 kHz) secure voice. This is a special schedule pertaining to encrypted voice baseband transmission over metallic facilities without regenerators.	Z1

Table 10-3. DCS Circuit Parameter Codes (Continued)

SERVICE	NARRATIVE DESCRIPTION OF DCS SERVICE	CIRCUIT PARAMETER CODE
	50,000 bits/sec (within 48 kHz) secure voice. This is a special schedule pertaining to encrypted voice baseband transmission over long-distance carrier facilities.	Z4
VFCT Systems	Voice frequency carrier telegraph, type 1. Up to 16 teletypewriter channels provided over a voice frequency circuit between carrier terminals.	D2
	Voice frequency carrier telegraph, type 2. Up to 26 teletypewriter channels provided over a voice frequency circuit between carrier terminals.	D1
AUTOVON: Access Lines	Voice grade	V2
	Special grade, such as AUTOVON switch access (2400 bits/sec) from the following: alternate voice data terminal, AUTODIN or DSSCS switch, secure voice terminal, secure voice cordless switchboard, SEVAC, VOCOM SWITCH, and other secure voice 4-wire switchboards.	S3
Trunks Inter-Switched	Voice grade	V2
	Special grade (no regenerators at either end)	S3
	Special grade (regenerators at both ends)	S1
	Special grade (regenerators at one end)	S2
AUTODIN: Access Lines	1200 or 2400 bits/sec	D1
	1200 bits/sec multiplexed. Includes service where user and AUTODIN switching center provide modems which are frequency division multiplexed to provide a number of channels on a single VF channel. This VF channel may be multiplexed with any compatible combination of 75-, 150-, 300-, or 600-baud modems not to exceed a total of 1200 bauds. VF bridging at transmission nodal points is employed to serve non-collocated users. See N2 and N3 for schedule pertaining to 75- to 150-baud DC-keyed access lines.	D2

Table 10-3. DCS Circuit Parameter Codes (Continued)

SERVICE	NARRATIVE DESCRIPTION OF DCS SERVICE	CIRCUIT PARAMETER CODE
Trunks	2400 bits/sec dedicated circuit from one AUTODIN switch to another.	D1
AUTOSEVOCOM:		
Access Lines	Secure voice terminal (2400 bits/sec) to VOCOM switch.	S1
	Secure voice terminal (2400 bits/sec) to 4-wire JOSS or 5-D switchboard, part of AUTOSEVOCOM.	S3
	Secure voice terminal (50 kilobit) to special 758 switch, cordless switchboard or VOCOM switch.	
	over metallic facilities without regenerators	Z2
	over long distance carrier facilities	Z4
	Secure voice terminal (50 kilobit) to AN/FTC-31	
	over metallic facilities without regenerators	Z1
	over long distance carrier facilities	Z4
Trunks	50 kilobit, over metallic facilities without regenerators.	Z3
	50 kilobit, over long-distance carrier facilities.	Z4
	2400 bits/sec (VOCOM switch to either VOCOM or special 758 switch).	S1
	2400 bits/sec (JOSS to either JOSS or cordless switchboard).	S3
	2400 bits/sec (SEVAC to JOSS or 5-D switchboard).	S3

Table 10-4. Comparison of DCA and Bell System Circuit Parameters — Part I

DCA CIRCUIT PARAMETER CODE	CLOSEST BELL SYSTEM EQUIVALENT CIRCUITS (Old Designation)	CLOSEST BELL SYSTEM EQUIVALENT CIRCUITS (New Designation)
S1	4B	C2
S2	(1/2) 4B (For envelope delay distortion only)	C2 (switched)
S3	(1/5) 4B (For envelope delay distortion only)	C3
V1	-	-
V2	-	-
D1	4B	C2
D2	4A	C1

Table 10-4. Comparison of DCA and Bell System Circuit Parameters — Part II

Characteristic	DCA Circuit Parameter Code	Bell System Nomenclature	
	D2	4A	C1
Frequency response (dB)			
0.3 - 2.7 kHz	-2 to +6		-2 to +6
1.0 - 2.4 kHz	-1 to +3		-1 to +3
0.3 - 3.0 kHz	-3 to +12		
0.3 - 2.6 kHz		-2 to +6	
0 5 - 2.4 kHz		-1 to +3	
Max delay distortion (μsec)			
1.0 - 2.4 kHz	1000	1000	1000
1.0 - 2.6 kHz	1750		
Max net loss variation (dB)	±4		
Short term		±3	±3
Short and long term		±4	±4
Max change in audio freq (Hz)	±5	±2	±10
Max allowable channel noise (dBrnc0) 3 kHz weighting		*	
0 - 50 Miles	31		31
51 - 100 Miles	34		34
101 - 400 Miles	37		37
401 - 1000 Miles	41		41
1001 - 1500 Miles	43		43
1501 - 2500 Miles	45		45
2501 - 4000 Miles	47		47
4001 - 8000 Miles	50		
8001 - 16000 Miles	53		
Max single tone interference below circuit noise in each above mileage category (dB)	3		
Impulse Noise Reference level 71 dBrnc0 or 72 dBrn0 voice band weighting	15	**	15
Terminal impedance 600 ohms (% tolerance)	±10 ***		
Composite data transmission level (dBm0)	-13		-12
Phase jitter peak to peak (degrees)	15		
Harmonic distortion (dBm0)	-40****		

* The allowable noise power at the receiving terminal is not to exceed -36 dBm using no frequency weighting.

** The impulse noise at the receiving terminals is measured with the 1556A impact set and the 2B noise measuring set using 144 weighting. Impulse noise limit is no more than 70 noise peaks above -30 dBm per hour.

*** For leased circuit, impedance is measured at 1000 Hz; for Government-owned circuits, impedance is measured at various frequencies across the band of interest.

**** Applies to the measurement of any harmonic of a 700-Hz test frequency introduced at a 10-dBm0 level.

Table 10-4. Comparison of DCA and Bell System Circuit Parameters — Part III

Characteristic	DCA S1/D1	Bell Sys 4B	Bell Sys C2	DCA S2	Bell Sys C2 1/2 4B	Bell Sys C2 Switched	DCA S3	Bell Sys 1/5 4B	Bell System C3* Access Line	Bell System C3* Trunk
Frequency response (dB) 0.3 - 3.0 kHz	-2 to +6	-2 to +6	-2 to +6	-1.5 to 4.5			-1 to +3		-08 to +3	-0.8 to +2
0.5 - 2.8 kHz	-1 to +3	-1 to +3	-1 to +3	-0.5 to -2			-0.5 to 1.5		-0.5 to 1.5	-0.5 to +1
Maximum envelope delay distortion (μsec) 0.5 - 2.8 kHz	3000	3000	3000	1500	1500	1500	600	600	650	500
0.6 - 2.6 kHz	1500	1500	1500	750	750	750	300	300	300	260
1.0 - 2.6 kHz	500	500	500	250	250	250	100	100	110	80
Max net loss variation (dB) short term	±4	±3	±3	±3			±2		±3	±3
Short and long term		±4	±4						±4	±4
Max change in audio frequency (Hz) ****	±5	±2	±10	±5**			±5**		±5	±5
Max allowable chnl noise (dBrnc0) 0-50 Miles	31	***	31				31		31	31
51-100 Miles	34		34	34			34		34	34
101-400 Miles	37		37	37			37		37	37
401-1000 Miles	41		41	41			41		41	41
1001-1500 Miles	43		43	43			43		43	43
1501-2500 Miles	45		45	45			45		45	45
2501-4000 Miles	47		47	47			47		47	47
4001-8000 Miles	50			50			50			
8001-16000 Miles	53			53						

* Conditioning limited to each interexchange or local access line - between the customer's station and switch center. Each trunk - between switching centers.

** Circuits within CONUS ±3 Hz.

*** Noise/background noise - the average noise power at the receiving terminal as measured with no frequency weighting shall not exceed -42 dBm0.

**** D1 allowable channel noise for Government-owned circuits 47 dBrnc0 for all distances shown above. Consider a satellite channel as equivalent to a 2000-mile landline channel in determining circuit length.

Table 10-4. Comparison of DCA and Bell System Circuit Parameters — Part III (Continued)

Characteristic	DCA S1/D1	Bell Sys 4B	Bell Sys C2	DCA S2	Bell Sys C2 1/2 4B	Bell Sys C2 Switched	DCA S3	Bell Sys 1/5 4B	Bell System C3 * Access Line	Bell System C3 * Trunk
Maximum single tone interference below circuit noise in each mileage category (dB)	3			3			3			
Impulse noise (max counts in 15 min above ref level)		*								
Ref level 71 dBrnc0 or 72 dBrn0 voice band wtg.	15		15	15			15			
Ref level 62 dBrn0 voice band wtg.									15	
Terminal impedance 600 ohm (% tolerance) **	±10			±10			±10			
Composite data transmission level (dBm0)	-13		-12	-13			-13		-10	-10
Phase jitter peak to peak (degrees)	15			15			15			
Harmonic distortion (dBm0) ***	-40			-40			-40			

* The impulse noise at the receiving terminals as measured with the 1556A impact set in conjunction with the 2B noise measuring set 144 weighting may exceed -30 dBm for no more than 70 noise peaks per hour.

** For leased circuits measured at 1000 Hz, for government-owned circuits measured across the frequency band of interest.

*** Applies to the measurement of any of the harmonics of a test frequency of 700 Hz introduced at a level of -10 dBm0.

Table 10-5. DCS Technical Schedules Circuit Parameters — Part I

Characteristic	Unit of Meas	S1	S2	S3	V1	V2	D1	D2	N (1-3)
a. Frequency Response kHz	dB								
0.3-2.7								-2 to +6	
0.3-3.0		-2 to +6	-1.5 to +4.5	-1 * to +3		-3 to +8	-2 to +6	-3 to +12	
0.4-2.8					-8 to +20				
0.5-2.8		-1 to +3	-0.5 to +2	0.5 * to +1.5			-1 to +3		
0.6-2.4				*	-7 to +12				
1.0-2.4				*				-1 to +3	
0.7-2.3				*		-1 to +3			

* For CONUS AUTOVON, frequency response may be 300-499 Hz, -0.8 to +3.0 dB; 500-2800 Hz, -0.5 to 1.5 dB; 2801-3000 Hz, -0.8 to +3.0 dB. For CONUS AUTOVON special interswitch trunks, frequency response may be 300-499 Hz, -0.8 to +2.0 dB; 500-2800 Hz, -0.5 to +1.0 dB; 2801-3000 Hz, -0.8 to +2.0 dB.

Table 10-5. DCS Technical Schedules Circuit Parameters — Part I (Continued)

Characteristic	Unit of Meas	S1	S2	S3	V1	V2	D1	D2	N (1-3)
b. Maximum envelope delay distortion	micro-sec								
kHz									
0.5-2.8		3000	1500	600			3000		
0.6-2.6		1500	750	300 *			1500		
1.0-2.4				*				1000	
1.0-2.6		500	250	100 *			500	1750	
c. Maximum net loss variation	dB	±4	±3	±2	±4	±2	±4	±4	
d. Maximum change in audio frequency	Hz	±5	±5***	±5***	±5	±5	±5**	±5	

* For CONUS AUTOVON, maximum envelope delay distortion is 1000-2600 Hz, 110 microseconds; 600-2600 Hz, 300 microseconds; 500-2800 Hz, 650 microseconds. For CONUS AUTOVON special grade interswitch trunks, maximum envelope delay distortion is 1000-2600 Hz, 80 microseconds; 600-2600 Hz, 260 microseconds; 500-2800 Hz, 500 microseconds.

** For type 2 VFCT terminal ±2 Hz.

*** Circuits within CONUS ±3 Hz.

Table 10-5. DCS Technical Schedules Circuit Parameters — Part I (Continued)

Characteristic	Unit of Meas	S1	S2	S3	V1	V2	D1	D2	N (1-3)
e. Minimum longitudinal balance	dB	40	40	40	40	40	40	40	
f. Maximum total peak telegraph distortion	%								20
g. Maximum mark or space bias distortion	%								12 *
h. Maximum allowable channel noise	dBrnc0								
0-50 miles		31	31	31	31	31	31	31	
51-100		34	34	34	34	34	34	34	
101-400		37	37	37	37	37	37	37	
401-1000		41	41	41	41	41	41	41	
1001-1500		43	43	43	43	43	43	43	
1501-2500		45	45	45	45	45	45	45	
2501-4000		47	47	47	47	47	47	47	
4001-8000		50	50	50	50	50	50	50	
8001-16000		53	53	53	53	53	53	53	
i. Maximum single tone interference below circuit noise in each mileage category	dB	3	3	3	3	3	3	3	

* For Government-owned circuits: 5%.

** D1 and D2 allowable channel noise for Government-owned circuits is 47 dBrnc0 for all distances shown above. Consider a satellite channel as equivalent to a 2000-mile landline channel in determining circuit length.

Table 10-5. DCS Technical Schedules Circuit Parameters — Part I (Continued)

Characteristic	Unit of Meas	S1	S2	S3	V1	V2	D1	D2	N (1-3)
j. Impulse noise ref level 71 dBrnc0 or 72 dBrn0 voice band weighting, For CONUS AUTOVON -20 dBm0	Max Counts in 15 min above ref level	15	15	15			15	15	
k. Terminal impedance * 600 ohms	% tol-erance	±10	±10	±10	±10	±10	±10	±10	
l. Composite data transmission level	dBm0	-13	-13	-13 **	-13	-13	-13	-13	
m. Phase jitter (peak to peak)	Degrees	15	15	15			15	15	
n. Harmonic distortion ***	dBm0	-40	-40	-40	-40	-40	-40	-40	

* For leased circuits measured at 1000 Hz; for Government-owned circuits measured across the frequency band of interest.

** For CONUS AUTOVON -10 dBm0.

*** Applies to the measurement of any of the harmonics of a test frequency of 700 Hz introduced at a level of -10 dBm0.

In the above table, loss frequency characteristics are given in terms of comparison to the measured loss at 1000 hertz. For example, in the S1 schedule the loss frequency characteristic should not exceed the range of 2 dB less loss (-) to 6 dB more loss (+) between 0.3-3.0 kHz when compared to the measured loss at 1000 hertz.

Table 10-5. DCS Technical Schedules Circuit Parameters — Part II

Schedules Z1 through Z3 establish the engineering parameters for the 50 kilobit per second encrypted voice transmission system designed to provide service within the approximate bandwidth of 10-50, 000 Hz over facilities wihtout regernators.

General

Mode of Operation	Full-Duplex
Termination	4-wire
Impedance - Source and Load	135 ohms, nominal mid-band, balanced
Signal Input (Baseband)	0 dBm (1.04V p-p)

CHARACTERISTIC	UNIT OF MEASURE	CIRCUIT PARAMETERS Z1	Z2 SUBSCRIBER TO SWITCH	Z2 SWITCH TO SUBSCRIBER	Z3
a. Line-up loss* kHz	dB				
0.01		+15		+15	
0.1		+13		+13	
1.0		+12		+12	
10.0		+20		+20	
50.0		+30		+30	
0.01-50.0			-2 to +2		-2 to +2
1.0 -40.0			-1 to +1		-1 to +1
b. Delay characteristic	Microsecond	See Figure 10-1			
c. Maximum loss** variation	dB	±4	±4	±4	±4
d. Noise characteristics***	dB (S+N)/N	> 20	> 20	> 20	> 20
e. Impulse noise	Max peaks per second exceeding 12 dB below peak signal level	1	1	1	1
f. Supervisory signal inputs	-	****	*****	*****	*****

* These are maximum values. Shorter circuits will have less and will generally correspond to the slope characteristic shown.

** Referred to line-up losses.

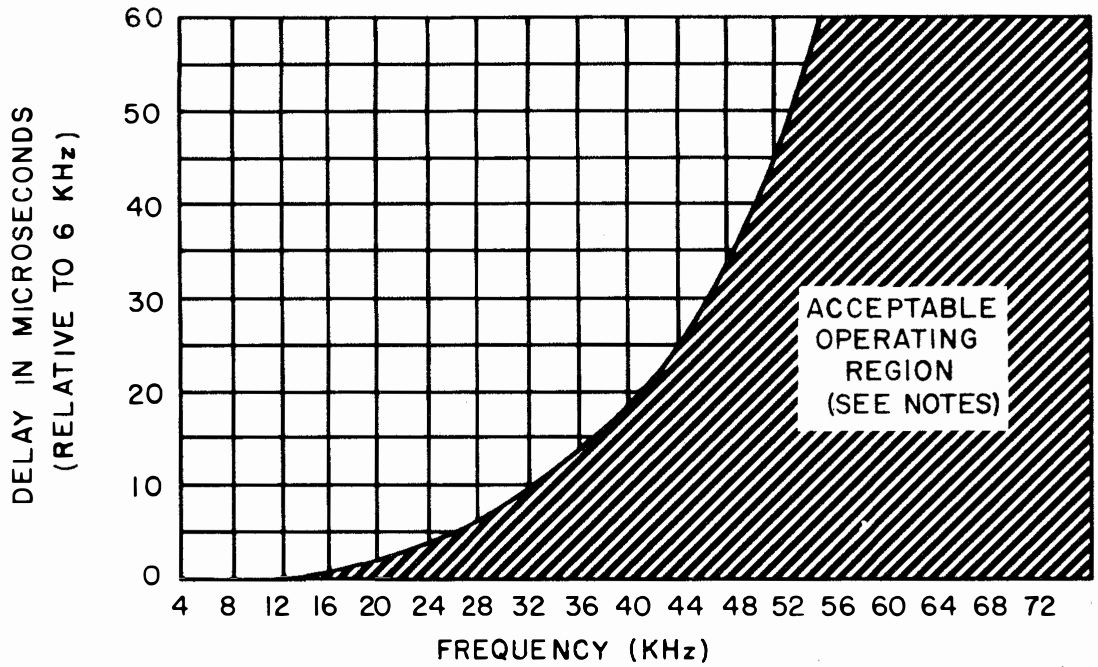
*** Signal plus noise of pseudo random signal at normal transmission level measured at the user terminal with a true RMS voltmeter and with the line terminated in 135 ohms. Noise is measured with same meter at the user terminal with signal removed and input terminated.

**** (Schedule Z1)

Ring Tone	1000 Hz (Range -6.5 to +5.0 dBm)
On Hook	2600 Hz at -21 dBm
Voice	-17.5 VU

***** (Schedules Z2 and Z3)

Ring Tone	1000 Hz (Range -6.5 to +5.0 dBm)
On Hook	2600 Hz at -21 dBm
Dial Pulsing	2600 Hz burst at -9 dBm
On Hook Return	2600 Hz at -9 dBm for nominal 260 (Range 220 to 320) milliseconds followed by 2600 Hz at -21 dBm
Voice	-17.5 VU



NOTES:

1. Above curve represents Envelope Delay Requirements. Limits are not specified below 6 kHz.

2. If the entire circuit consists of properly amplitude equalized twisted pair cable, from which all loading coils and bridge taps have been removed, no delay equalization should be required. Given the correct frequency response over the range of .01 to 50 kHz (no discontinuities or sharp rolloffs), envelope delay will not normally be an item for concern on cable pairs.

3. Should the circuit contain carrier facilities, delay equalization must be employed such that the delay versus frequency response of the circuit is a smoothly and continuously increasing function of frequency, which falls within the shaded area of this figure.

Figure 10-1. Relative Envelope Delay versus Frequency Limits

Table 10-5. DCS Technical Schedules Circuit Parameters — Part III

Schedule Z4 establishes the engineering parameters for the 50 kilobit/second encrypted voice transmission system designed to provide service, within a bandwidth of 48 kHz, over long distance carrier facilities.

Characteristic	Unit of Measurement	Schedule Z4 4-Wire Carrier Full Duplex Operation Subscriber to Subscriber or Switch to Switch
Nominal data signal amplitude (input/output)	Volts, peak-to-peak (P-P)	1
Impedance (balanced input/output)	Ohms	135
Data rate at baseband (NRZ)	Kilobits/second	50
Jitter from terminal equipment (maximum)	% Isochronous distortion (=P-P jitter)	20
Jitter to terminal equipment (maximum)	% Isochronous distortion (=P-P jitter) (Assumes 0-20% jitter from terminal equipment)	33
Error rate objective	Error rate/time	*
On-hook signal from terminal equipment	Hz	2600 at -21 dBm
Ringing signal to terminal equipment	Hz	1000 at -6.5 dBm
Dial signal from terminal equipment	Tone bursts	2600 Hz bursts at -9 dBm, 10 PPS, 61% break
On-hook signal following off-hook from terminal equipment	Hz	2600 Hz at -9 dBm for approximately 260 milliseconds
Forwarding switching time (approximately)	Milliseconds	400 (following end of last dialed digit)

*The burst rate shall not exceed one error burst per minute averaged over a 1-hour test period. One error burst is not to exceed 350 bits averaged over a 1-hour test period. The average number of bits per burst is equal to the total of bit errors divided by the number of bursts.

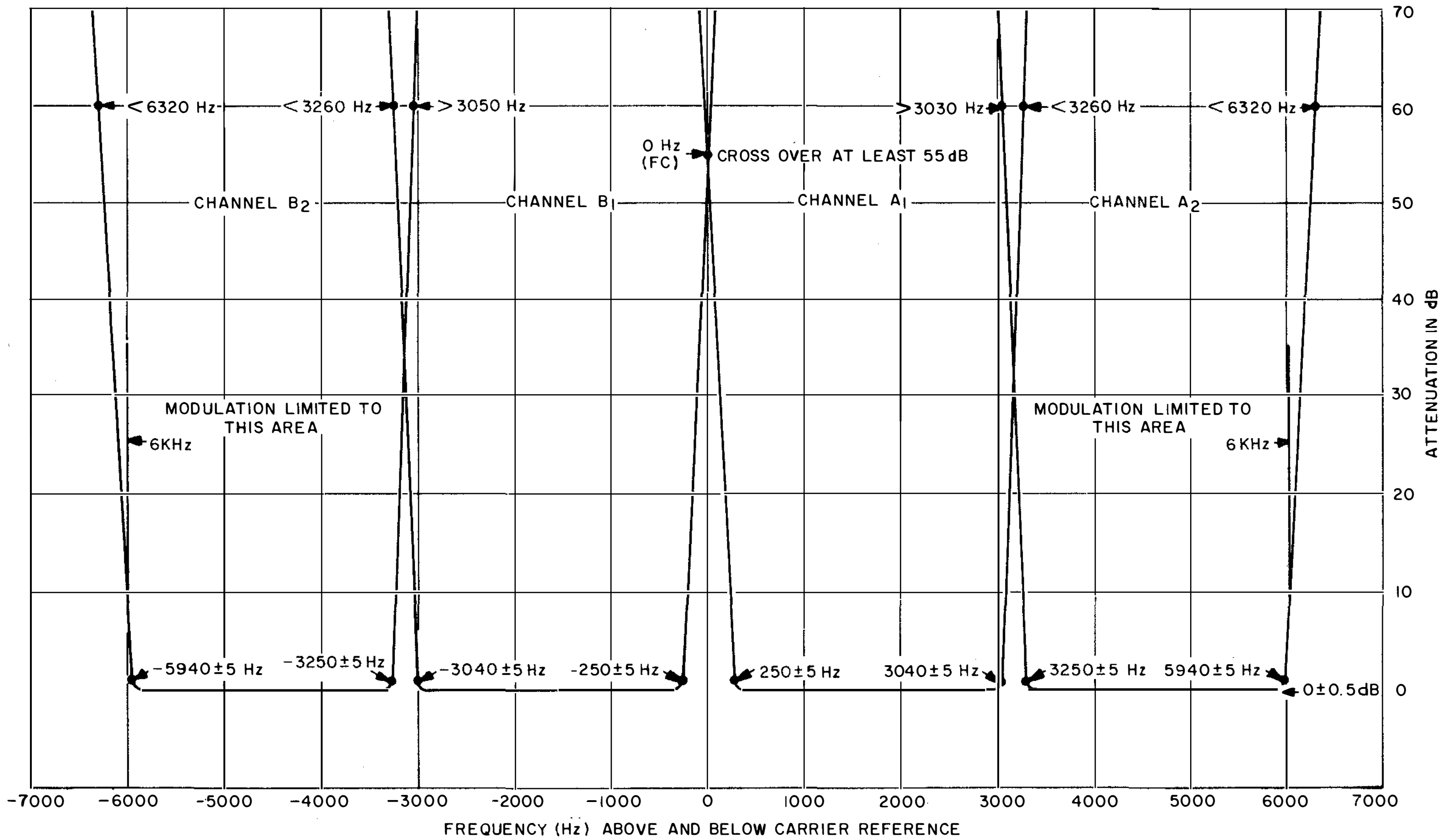


Figure 10-2. Independent Sideband Transmitter and Receiver Frequency Response

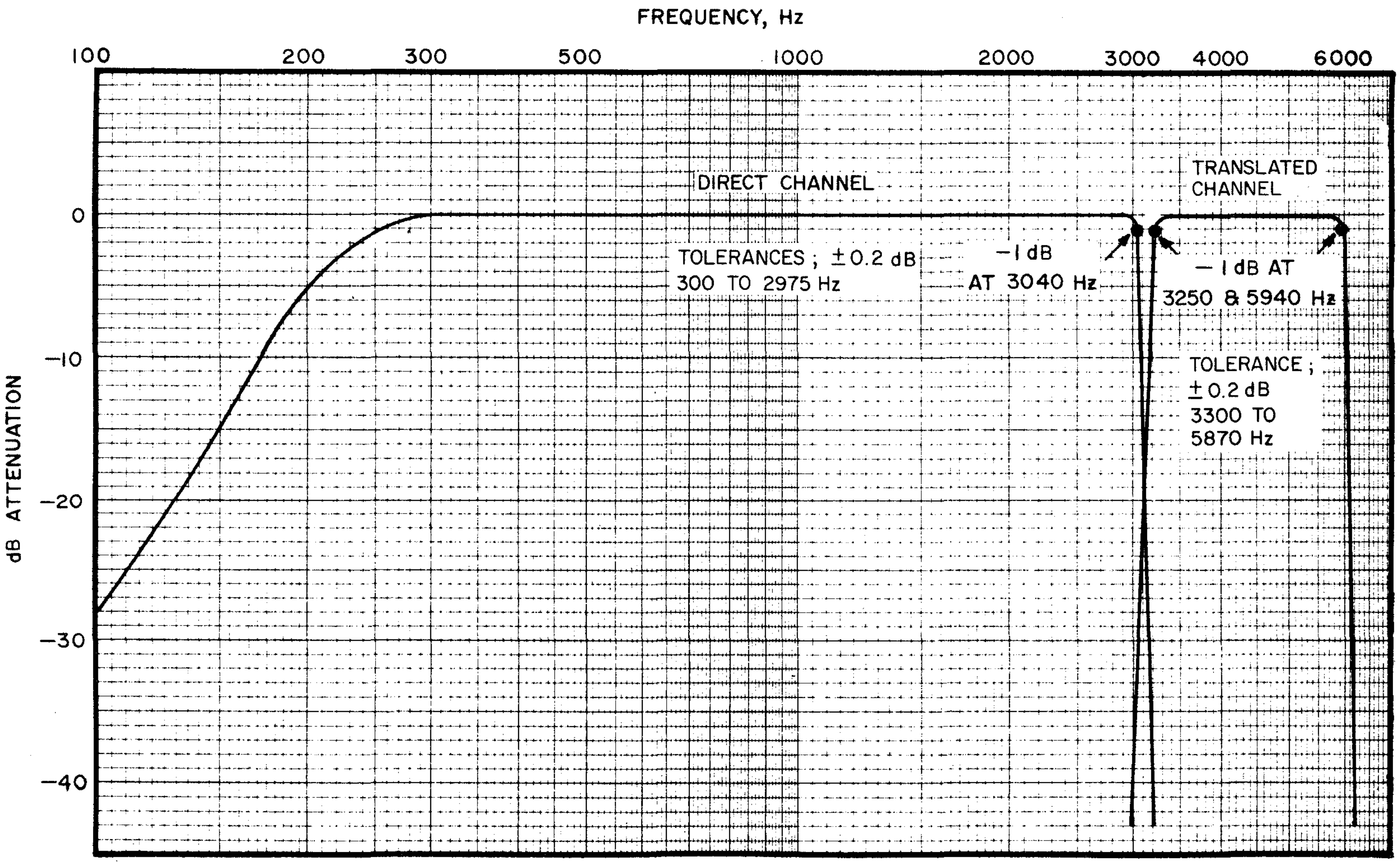


Figure 10-3. Overall Frequency Response of Multiplexer and Demultiplexer

Table 10-6. HF Radio Transmission Criteria 3-kHz Circuit

Characteristic	Standard
Channel Spacing, Nominal Bandwidth	3-kHz
Maximum Bandwidth	12-kHz
Bandpass	Channel A_1 and B_1 250 to 3040-kHz, ±5 Hz Channel A_2 and B_2 360 to 3040-kHz, ±5 Hz
Frequency Response	±0.5 dB over bandpass each channel
Noise Each Channel	55 dBm0 "c"
Frequency Stability Each Channel	±1 Hz
Cross Talk Each Channel	Not greater than -39 dBm0 "c'
Envelope Delay	Channel A_1 and B_1 1.2 milliseconds from 250 to 3040 Hz Channel A_2 and B_2 1.2 milliseconds from 360 to 2990 Hz
Transmitter, Input Level Each Channel	-9 dBm for speech, 0-dBm for test tone
Receiver, Output Level Each Channel	-0 dBm for test tone

Table 10-7. HF Receiver Performance and Interface Criteria

Characteristic	Criteria
Frequency Range	2-30 MHz
Output	Two 6-kHz channels or four 3-kHz channels
Input Impedance	50 Ohms unbalanced
Output Impedance Each Channel	600 Ohms balanced to ground. Minimum return loss of 26 dB from 250-3040 Hz. Longitudinal current at least 40 dB below input level.
Output Level	0-dBm each channel
Sensitivity Each Channel	$\frac{\text{Signal + Noise}}{\text{Noise}}$ greater than 10 dB with 0.2 μvolt input
Automatic Gain Control Each Channel	±1.5 dB with variation of input from 1.0 μvolt to 1.0 volt
Envelope Delay	<25 μsec between 550 to 2600 Hz and <500 μsec between 370 and 3040 Hz
Frequency Accuracy	Within 1 part in 10^8
Frequency Stability	1 part in 10^8 per day and not to exceed 5 parts in 10^8 in 30 days.
Phase Stability	Within 0.0524 radians in 10 milliseconds controlled by external standard. Within 0.0873 radians in 10 milliseconds controlled by internal standard.
Image Rejection	>100 dB
IF Rejection	>100 dB
Tuning	Continuous with readout in 100 Hz increments or not less than 20 preset selectable frequencies.
Mean Time Between Failures	12,000 hours for unit, 20,000 hours for individual vacuum tubes.

Table 10-8. HF Transmitter Performance and Interface Criteria

Characteristic	Criteria
Input	1 to 4 voice frequency 3-kHz audio channels
Emission	3A9A, 6A9B, 9A9B, or 12A9B
Bandpass	Channels A_1 and B_1, 250-3040 Hz ±5 Hz Channels A_2 and B_2, 360-3040 Hz ±5 Hz
Frequency Response	±0.5 dB over bandpass each channel
Adjacent Channel Separation	70 dB rejection of unwanted sideband
Output Power	Distributed evenly over each channel transmitted
Input Impedance for Each Channel	600 Ohm balanced to ground, minimum return loss of 26 dB, 250-3040 Hz, longitudinal currents at least 40 dB below reference input-level.
Input Level Range	-20 dBm to +4 dBm
Idle Noise Each Channel	55 dB below input required for full rated output
Envelope Delay	25 μsec between 550 to 2600 Hz and 500 μsec between 370 and 3040 Hz.
Tuning	Increments not greater than 100 Hz.
Output Impedance	50 Ohm with a maximum VSWR of 2:1
Frequency Accuracy	Within 1 part in 10^8
Frequency Stability	1 part in 10^8 per day and not to exceed 5 parts in 10^8 in 30 days
Carrier Level Suppression Control	Variable to at least 55 dB below the rms power of a single tone at full rated output
Carrier Level Control Stabilization	±3.0 dB at all output levels when using maximum carrier suppression.
Spurious Emission Suppression	80 dB when more than 100% outside bandpass 25 dB when outside bandpass to 100% outside bandpass
Mean Time Between Failures	12,000 hours for unit. For individual tubes: 5-24 watt power output . . . . 20,000 hr. 25-500 watt power output . . . . 10,000 hr. 500 watt power output . . . . . . 5,000 hr.
Acoustic Noise	65 dB when 10 feet from transmitter

Table 10-9. Voice Frequency Carrier Telegraph Terminal Equipment Performance and Interface Criteria

Characteristic	Criteria
Input and Output, DC Channels	High or low level DC keying 1 to 18 channels
Input Impedance DC Channels	High level 100 to 200 Ohms Low level 6000 Ohms
Output Impedance DC Channels	High level <150 Ohms Low level <50 Ohms
Audio Frequency (AF) Output and Input	1 to 18 channels spaced at 170 Hz modulated with ±42.5 Hz as follows: (see channel table below)
Noise, AF Channels	Not to exceed 20 dBrnc at output
Input and Output Impedance, AF Channels	600 Ohm balanced to ground, minimum return loss of 26 dB from 370-3400 Hz, longitudinal current at least 40 dB below input reference level.
Harmonic Distortion, AF Channels	Each channel center frequency harmonic distortion at least 60 dB below signal level
AF Signal Input Minimum	-20.7 dBm each channel
Fade Limit	-50.0 dBm each channel for diversity system -30.0 dBm each channel for non diversity system.

Channel Designation	Mark Frequency (Hz)	Center Frequency (Hz)	Space Frequency (Hz)
1	382.5	425	467.5
2	552.5	595	637.5
3	722.5	765	807.5
4	892.5	935	977.5
5	1062.5	1105	1147.5
6	1232.5	1275	1317.5
7	1402.5	1445	1487.5
8	1572.5	1615	1657.5
9	1742.5	1785	1827.5
10	1912.5	1955	1997.5
11	2082.5	2125	2167.5
12	2252.5	2295	2337.5
13	2422.5	2465	2507.5
14	2592.5	2635	2677.5
15	2762.5	2805	2847.5
16	2932.5	2975	3017.5
17	3102.5	3145	3187.5
18	3272.5	3315	3357.5

Table 10-10. Wide Band Multiplex Performance and Interface Criteria

Characteristic	Criteria
Input Frequency Band, Each Channel	300 to 3400 Hz
Input and Output Impedance, Each Channel	600 Ohm balanced to ground, longitudinal current at least 40 dB below input level
Group Output	12 channels multiplexed and translated to 60-108 kHz band
Input Output Impedance, Each Group	135 Ohm balanced to ground. Minimum return loss 20 dB, measured for each of the 12 channels
Supergroup Output	5 groups multiplexed and translated to 312-552 kHz band
Input Output Impedance, Each Supergroup	75 Ohms unbalanced, minimum return loss 20 dB, measured for each of the 5 groups
Test Tone Level, Channel Input	-16 dBm
Test Tone Level, Channel Output	+7 dB ±0.1 dB
Test Tone Level, Group Transmitter Input	-34.5 dBm ±0.75 dBm
Test Tone Level, Group Receiver Output	-12 dBm
Test Tone Level, Supergroup Transmitter Input	-18 dBm ±0.5 dBm
Test Tone Level, Supergroup Receiver Output	-28 dBm ±0.5 dBm
Channel Insertion Loss Relative to 1000 Hz	600 - 2400 Hz ±0.35 dB 400 - 3000 Hz -0.35 dB to +0.75 dB 300 - 3400 Hz
Group Insertion Loss Relative to 83 kHz	60 - 108 kHz ±0.2 dB
Supergroup Insertion Loss	312-552 kHz -1.0 dB Any 48 kHz band limited to 0.5 dB
Channel Envelope Delay	600 - 3200 Hz . . . . <90 μsec 1000 - 2500 Hz . . . . <55 μsec
Group Envelope Delay	60 - 108 kHz . . . . <15 μsec 68 - 100 kHz . . . . <5 μsec Any 4-kHz channel portion less than 2 μsec
Supergroup Envelope Delay	312 - 552 kHz . . . . <5 μsec

Table 10-11. Quality Control Schedule

TYPE TESTS	D. C.		Voice Channel & Spare VF Channels		VFCT		150-2400 Digital Modems		Secure Voice	
	In Service	Out of Service	In Service	Out Service	In Service	Out Service	In Service	Out Service	In Service	Out Service
Test Tone Level			72 (2)	Q (1)		Q (1)		Q (1)		Q (1)
Voltage Level		M (1)				M (1)				
Current Level		M (1)				M (1)				
Maximum Allowable Channel Noise			72	Q (1)		Q (1)		Q		Q
Impulse Noise				Q		Q (1)		Q (1)		Q (1)
Frequency Response				Q		Q (1)		Q (1)		Q (1)
Envelop Delay Distortion								Q (1)		Q (1)
Maximum Net Loss Variation				Q		Q		Q (1)		Q (1)
Maximum Change in Audio Frequency				Q		Q (1)		Q (1)		Q (1)
Minimum Longitu-dinal Balance				Y		Y		Y		Y
Maximum Single Tone Interference				Y		Y		Y		Y
Terminal Impedance				Y		Y		Y		Y
Composite Data Transmission Level			72 (4)		72 (3)		72 (3)		72 (3)	
Harmonic Distortion				Y		Y		Y		Y

Table 10-11. Quality Control Schedule (Continued)

TYPE TESTS	D. C.		Voice Channel & Spare VF Channels		VFCT		150-2400 Digital Modems		Secure Voice	
	In Service	Out of Service	In Service	Out Service	In Service	Out Service	In Service	Out Service	In Service	Out Service
Phase Jitter				Y		Y		Y		Y
Total Peak Distortion	72	M (1)			72	M (1)	72		72	
Signaling Test				Y						Y
Mark/Space Current Balance		Q								

LEGEND:

72 - Every 72 hours

M - Monthly

Q - Quarterly

Y - Yearly

NOTE 1. These tests will be conducted after equipment substitution or maintenance and after circuit reroute.

NOTE 2. Voice circuits having in-band tone on idle signaling always have a tone present. The level of this tone should be checked at the monitor jacks. It is very important that the monitor jacks are used when checking this tone as false rings will be caused by breaking the circuit. The proper tone level in the channel is specified in chapter 3 or the CLR.

NOTE 3. The composite signal level should be measured at the monitor jack and compared against a known reading on a VU or db meter which is generated from a known source and corresponds to a channel level of -13 dbm0.

NOTE 4. The speech level should be monitored at the monitor jack and compared to a known reading which corresponds to a channel level of -12 VU when measured at the 0 dbm test level point.

Table 10-12. Noise Power Conversion

PICO-WATTS	MILLI-WATTS	dBm	NEPERS	NOISE WEIGHTING				
				C-1000 Hz dBrn	C-0-3 kHz dBrnc	FIA 1000 Hz dBa	FIA 0-3 kHz dBa	PSOPHOMETRIC 800 Hz dBm
1.0	10^{-9}	-90	-10.4	0				-89
1.3	0.13×10^{-8}	-89	-10.2	1				-88
1.6	0.16×10^{-8}	-88	-10.1	2	0			-87
2.0	0.20×10^{-8}	-87	-10.0	3	1			-86
2.5	0.25×10^{-8}	-86	-9.90	4	2			-85
3.2	0.32×10^{-8}	-85	-9.79	5	3	0		-84
4.0	0.40×10^{-8}	-84	-9.67	6	4	1		-83
5.0	0.50×10^{-8}	-83	-9.55	7	5	2		-82
6.3	0.63×10^{-8}	-82	-9.44	8	6	3	0	-81
7.9	0.80×10^{-8}	-81	-9.32	9	7	4	1	-80
10	10^{-8}	-80	-9.21	10	8	5	2	-79
1.3X10	0.13×10^{-7}	-79	-9.09	11	9	6	3	-78
1.6X10	0.16×10^{-7}	-78	-8.98	12	10	7	4	-77
2.0X10	0.20×10^{-7}	-77	-8.87	13	11	8	5	-76
2.5X10	0.25×10^{-7}	-76	-8.75	14	12	9	6	-75
3.2X10	0.32×10^{-7}	-75	-8.63	15	13	10	7	-74
4.0X10	0.40×10^{-7}	-74	-8.52	16	14	11	8	-73
5.0X10	0.50×10^{-7}	-73	-8.40	17	15	12	9	-72
6.3X10	0.63×10^{-7}	-72	-8.29	18	16	13	10	-71
7.9X10	0.80×10^{-7}	-71	-8.17	19	17	14	11	-70
10^{-2}	10^{-7}	-70	-8.06	20	18	15	12	-69

Table 10-12. Noise Power Conversion (Continued)

PICO-WATTS	MILLI-WATTS	dBm	NEPERS	NOISE WEIGHTING C-1000 Hz dBrn	C- 0-3 kHz dBrnc	FIA 1000 Hz dBa	FIA 0-3 kHz dBa	PSOPHOMETRIC 800 Hz dBm
$1.3X10^2$	$0.13X10^{-6}$	-69	-7.94	21	19	16	13	-68
$1.6X10^2$	$0.16X10^{-6}$	-68	-7.83	22	20	17	14	-67
$2.0X10^2$	$0.20X10^{-6}$	-67	-7.71	23	21	18	15	-66
$2.5X10^2$	$0.25X10^{-6}$	-66	-7.60	24	22	19	16	-65
$3.2X10^2$	$0.32X10^{-6}$	-65	-7.48	25	23	20	17	-64
$4.0X10^2$	$0.40X10^{-6}$	-64	-7.37	26	24	21	18	-63
$5.0X10^2$	$0.50X10^{-6}$	-63	-7.25	27	25	22	19	-62
$6.3X10^2$	$0.63X10^{-6}$	-62	-7.14	28	26	23	20	-61
$7.9X10^2$	$0.80X10^{-6}$	-61	-7.02	29	27	24	21	-60
10^3	10^{-6}	-60	-6.91	30	28	25	22	-59
$1.3X10^3$	$0.13X10^{-5}$	-59	-6.79	31	29	26	23	-58
$1.6X10^3$	$0.16X10^{-5}$	-58	-6.68	32	30	27	24	-57
$2.0X10^3$	$0.20X10^{-5}$	-57	-6.56	33	31	28	25	-56
$2.5X10^3$	$0.25X10^{-5}$	-56	-6.45	34	32	29	26	-55
$3.2X10^3$	$0.32X10^{-5}$	-55	-6.33	35	33	30	27	-54
$4.0X10^3$	$0.40X10^{-5}$	-54	-6.22	36	34	31	28	-53
$5.0X10^3$	$0.50X10^{-5}$	-53	-6.10	37	35	32	29	-52
$6.3X10^3$	$0.63X10^{-5}$	-52	-5.99	38	36	33	30	-51
$7.9X10^3$	$0.80X10^{-5}$	-51	-5.87	39	37	34	31	-50
10^4	10^{-5}	-50	-5.76	40	38	35	32	-49

Table 10-12. Noise Power Conversion (Continued)

PICO-WATTS	MILLI-WATTS	dBm	NEPERS	NOISE WEIGHTING				
				C-1000 Hz dBrn	C-0-3 kHz dBrnc	FIA 1000 Hz dBa	FIA 0-3 kHz dBa	PSOPHOMETRIC 800 Hz dBm
1.3×10^{4}	0.13×10^{-4}	-49	-5.64	41	39	36	33	-48
1.6×10^{4}	0.16×10^{-4}	-48	-5.52	42	40	37	34	-47
2.0×10^{4}	0.20×10^{-4}	-47	-5.41	43	41	38	35	-46
2.5×10^{4}	0.25×10^{-4}	-46	-5.30	44	42	39	36	-45
3.2×10^{4}	0.32×10^{-4}	-45	-5.18	45	43	40	37	-44
4.0×10^{4}	0.40×10^{-4}	-44	-5.06	46	44	41	38	-43
5.0×10^{4}	0.50×10^{-4}	-43	-4.95	47	45	42	39	-42
6.3×10^{4}	0.63×10^{-4}	-42	-4.84	48	46	43	40	-41
7.9×10^{4}	0.80×10^{-4}	-41	-4.72	49	47	44	41	-40
10^{5}	10^{-4}	-40	-4.61	50	48	45	42	-39
1.3×10^{5}	0.13×10^{-3}	-39	-4.49	51	49	46	43	-38
1.6×10^{5}	0.16×10^{-3}	-38	-4.37	52	50	47	44	-37
2.0×10^{5}	0.20×10^{-3}	-37	-4.26	53	51	48	45	-36
2.5×10^{5}	0.25×10^{-3}	-36	-4.14	54	52	49	46	-35
3.2×10^{5}	0.32×10^{-3}	-35	-4.03	55	53	50	47	-34
4.0×10^{5}	0.40×10^{-3}	-34	-3.91	56	54	51	48	-33
5.0×10^{5}	0.50×10^{-3}	-33	-3.80	57	55	52	49	-32
6.3×10^{5}	0.63×10^{-3}	-32	-3.68	58	56	53	50	-31
7.9×10^{5}	0.80×10^{-3}	-31	-3.57	59	57	54	51	-30
10^{6}	10^{-3}	-30	-3.45	60	58	55	52	-29

Table 10-12. Noise Power Conversion (Continued)

PICO-WATTS	MILLI-WATTS	dBm	NEPERS	NOISE WEIGHTING C-1000 Hz dBrn	C-0-3 kHz dBrnc	FIA 1000 Hz dBa	FIA 0-3 kHz dBa	PSOPHO-METRIC 800 Hz dBm
1.3×10^6	0.13×10^{-2}	-29	-3.34	61	59	56	53	-28
1.6×10^6	0.16×10^{-2}	-28	-3.22	62	60	57	54	-27
2.0×10^6	0.20×10^{-2}	-27	-3.11	63	61	58	55	-26
2.5×10^6	0.25×10^{-2}	-26	-2.99	64	62	59	56	-25
3.2×10^6	0.32×10^{-2}	-25	-2.88	65	63	60	57	-24
4.0×10^6	0.40×10^{-2}	-24	-2.76	66	64	61	58	-23
5.0×10^6	0.50×10^{-2}	-23	-2.65	67	65	62	59	-22
6.3×10^6	0.63×10^{-2}	-22	-2.53	68	66	63	60	-21
7.9×10^6	0.80×10^{-2}	-21	-2.42	69	67	64	61	-20
10^7	10^{-2}	-20	-2.30	70	68	65	62	-19
1.3×10^7	0.13×10^{-1}	-19	-2.19	71	69	66	63	-18
1.6×10^7	0.16×10^{-1}	-18	-2.07	72	70	67	64	-17
2.0×10^7	0.20×10^{-1}	-17	-1.96	73	71	68	65	-16
2.5×10^7	0.25×10^{-1}	-16	-1.84	74	72	69	66	-15
3.2×10^7	0.32×10^{-1}	-15	-1.73	75	73	70	67	-14
4.0×10^7	0.40×10^{-1}	-14	-1.61	76	74	71	68	-13
5.0×10^7	0.50×10^{-1}	-13	-1.50	77	75	72	69	-12
6.3×10^7	0.63×10^{-1}	-12	-1.38	78	76	73	70	-11
7.9×10^7	0.80×10^{-1}	-11	-1.27	79	77	74	71	-10
10^8	10^{-1}	-10	-1.15	80	78	75	72	- 9

Table 10-12. Noise Power Conversion (Continued)

PICO-WATTS	MILLI-WATTS	dBm	NEPERS	NOISE WEIGHTING				
				C-1000 Hz dBrn	C-0-3 kHz dBrnc	FIA 1000 Hz dBa	FIA 0-3 kHz dBa	PSOPHOMETRIC 800 Hz dBm
1.3×10^8	0.13	-9	-1.04	81	79	76	73	-8
1.6×10^8	0.16	-8	-0.921	82	80	77	74	-7
2.0×10^8	0.20	-7	-0.806	83	81	78	75	-6
2.5×10^8	0.25	-6	-0.691	84	82	79	76	-5
3.2×10^8	0.32	-5	-0.576	85	83	80	77	-4
4.0×10^8	0.40	-4	-0.460	86	84	81	78	-3
5.0×10^8	0.50	-3	-0.345	87	85	82	79	-2
6.3×10^8	0.63	-2	-0.230	88	86	83	80	-1
7.9×10^8	0.80	-1	-0.115	89	87	84	81	0
10^9	1.0	0	0	90	88	85	82	+1

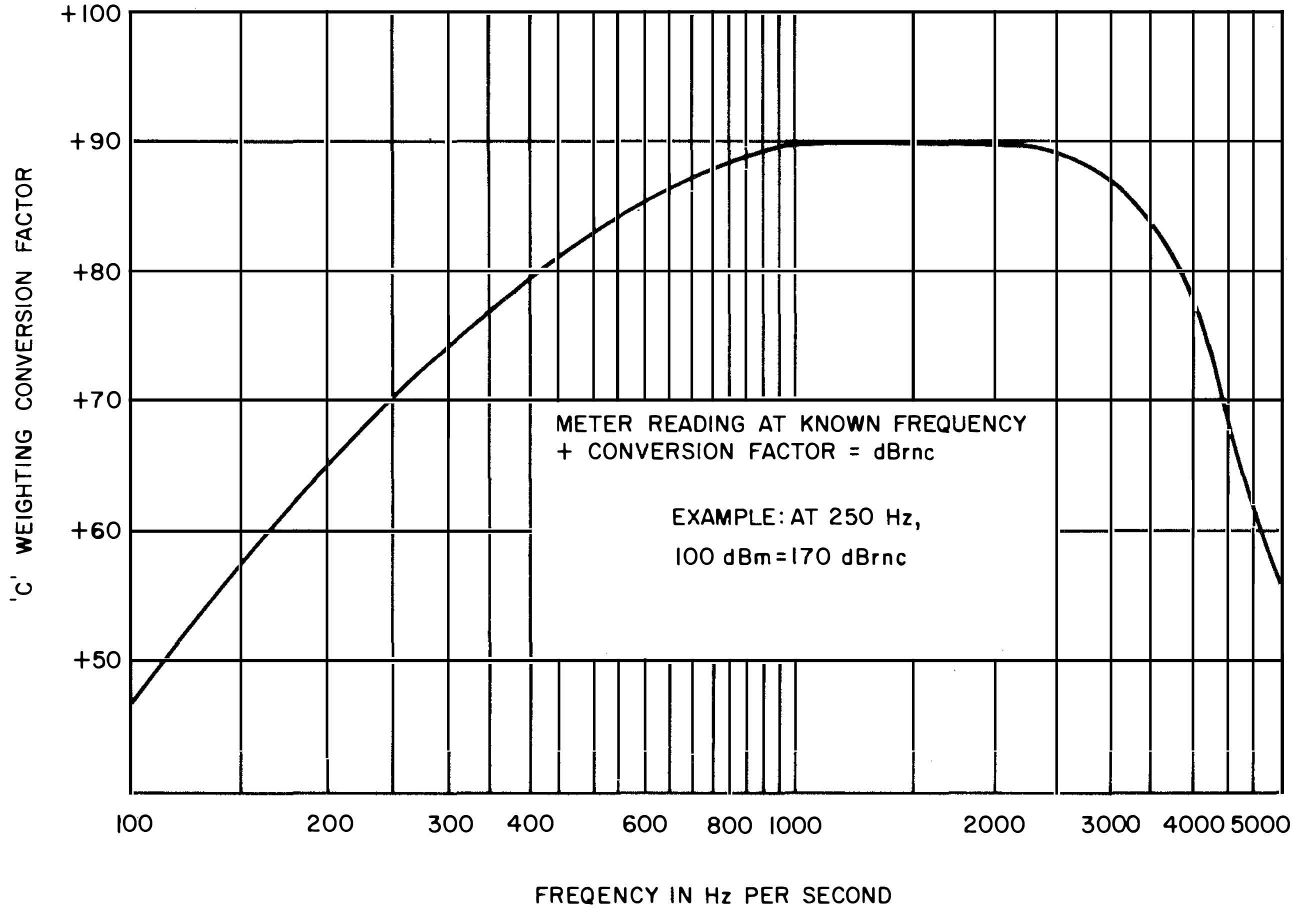


Figure 10-4. Conversion dBm to dBrnc

Table 10-13. Definition of Terms

TERM	DEFINITION
dBm	A power ratio referred to one milliwatt in 600 ohms. The power level at any point in a transmission system is the ratio of the power at that point to some arbitrary amount of power chosen as reference.
Noise weighting	A specific amplitude-frequency characteristic which approximates the effect of noise components at various frequencies upon an average listener using a particular class of telephone set.
dBm (psoph)	Circuit noise in dBm, measured with psophometric weighting.
Psophometric weighting	A noise weighting established by the International Consultative Committee for Telephony (CCIF, now CCITT), designated as CCIF-1951 weighting, for use in a noise measuring set or "Psophometer." The shape of this characteristic is virtually identical to that of F1A weighting. The Psophometer is, however, calibrated with a tone of 800 Hz, 0 dBm, instead of 1000 Hz, dBm. This introduces a -1 dB adjustment factor when converting between dBm and dBm (psoph).
C-message weighting	A noise weighting used in a noise measurement set to measure noise on a line that would be terminated by a 500-type or similar telephone set. The meter scale readings are in dBrn (C-Message), or dBrnc.
dBrn	Noise power, in dB referred to 1.0 picowatts (-90 dBm) with no weighting except for limiting the bandwidth of the measuring instrument to the 30-3000 Hz band.
dBrnc	C-Message weighted circuit noise power, in dB referred to 1.0 picowatts (-90 dBm), which is 0 dBrn.
dBm0"C"	dBm zero referenced and "C" weighted. These units do not include a specification of the transmission level at which they were (or, are to be) measured. A corresponding set of units, defined as above except that they are referred to a point of Zero Transmission Level, is as follows: Absolute units — Referred to zero transmission level dBrnc — dBrnc0 dBm (psoph) — dBm0p
pwp	Noise power in picowatts (10^{-12} watts, psophometrically weighted).
vu	Volume unit, the unit of measurement for electrical speech power in communication work as measured by a vu meter in the prescribed manner. The vu meter is a volume indicator conforming to American Standards Association c 1615-1942. It has a dB scale and specified dynamic and other characteristics in order to obtain correlated readings of speech power necessitated by the rapid fluctuation in level of voice currents. Zero vu equals zero dBm in measurement of sine wave test tone power.

CHAPTER 11

TESTING AND DESIGN VERIFICATION

11.1 GENERAL

Acceptance testing and design verification are the final steps in acquiring a system, subsystem, or unit of hardware. The major objectives of the acceptance test and design verification program are to ensure that (1) system overall performance is of maximum benefit to the Government, (2) installation and equipment documentation is available for maintenance purposes, and (3) contractual obligations have been fulfilled. Acceptance testing and design verification are just as much a part of the equipment installation as is the acquisition of the equipment itself. The successful completion of the planned acceptance tests and design verification program signifies that the items of concern are ready for operational use.

Periodic system tests are performed to determine the effectiveness of the equipments as installed. These tests also help to evaluate equipment maintenance and determine when equipment updating is required.

11.2 ACCEPTANCE TESTS

Acceptance tests are divided into two major groups: (1) those required for procurement and checkout of a new major system and (2) those required for subsystem and unit testing upon modernizing or increasing the capabilities of a communications station with "off-the-shelf" or production-run equipments.

11.2.1 Major System Testing

Tests required for the acceptance of a new major system start with the initial system design and continue throughout installation until final acceptance. Accordingly, the tests are divided into categories I, II and III test phases, which are described briefly as follows:

a. Category I Testing. This testing is conducted during system development and is concerned with individual components. It allows for redesign and refinement of the product.

b. Category II Testing. This testing is accomplished to validate system design and consists of testing and evaluating subsystems through the mating process that progresses into a complete system. This testing is accomplished for major system procurement where it is necessary to prove system compatibility and to expose any requirements for system redesign. It is a joint effort by Government and contractor to allow continued development of the system.

c. Category III Testing. This testing is performed to prove system maintainability, operability, and supportability within the planned skill levels of the assigned personnel. To allow realistic evaluation, category III testing is accomplished by user personnel.

The plan for accomplishing categories I, II and II testing is developed as a part of the total system acquisition package. Testing is done under the direction of the system project office assisted by field activity personnel. The system sponsor may participate in the testing to assure himself of system performance. Upon successful completion of category III testing, the system is ready for operational use.

11.2.2 Subsystem and Unit Acceptance Testing

Subsystem and unit acceptance testing must be accomplished for all newly installed units or subsystems to determine their ability to operate properly as an integrated part of the overall operational system. Whenever a unit of hardware or subsystem is installed an acceptance test program must be conducted. The successful completion of this acceptance test program will constitute acceptance for operational use by both the Government and operating personnel. The acceptance test program may range from simple meter checks to complex operational tests depending upon the type and quantity of equipments installed. When an acceptance test program for hardware installations is being planned, the major considerations are as follows:

a. User requirements.

b. Verification of system capabilities (demonstration of unit or system).

c. Duration of testing.

d. Manpower, test equipment, and cost.

e. Procedures to be followed if minimum requirements are not met.

Since the individual equipments involved are usually items that have been previously subjected to acceptance tests for the Navy, it is necessary to test the equipment only for its intended operational purpose. Re-measuring and rechecking of fixed characteristics defined by manufacturing specifications, or electronic realignment of individual equipments of a system is not normally required at the time of installation. However, checks of system characteristics that are controlled by tuning, peaking or otherwise adjusting the newly installed subsystem or unit must be included as part of the acceptance testing.

11.2.3 Acceptance Test Plan

The acceptance test plan is a written document which prescribes an orderly procedure to accomplish the tests and defines the extent of the testing. The test plan consists of two basic parts, the test directive and the test procedure. The salient factors to be considered when writing a test plan are outlined below:

a. Test Directive

(1) Introduction. Give general or background information leading up to publication of the test directive authority for and priority of the test program: mention any previous testing and related projects to be completed.

(2) Purpose of the Test. State briefly the reason for the test and include a generalized statement of the objectives.

(3) Scope of the Test. Specify detailed objectives that must be met to fulfill the purpose of the test.

(4) Method of Conducting the Test. Describe the manner and sequence in which subsystem or system tests are to be conducted. Include prerequisites for the condition of the system.

(5) Security. Classify, as necessary, equipment, tests, test results, documentation and other material related to the test program.

(6) Test Environment and Test Items. Describe the items to be tested and the environment(s) in which tests will be conducted.

(7) Organizations and Responsibilities. Provide an organizational breakdown showing participating units, functions, and specific responsibilities necessary for a timely and successful test program.

(8) Resources. Specify the resources required and how and where they will be used. Include equipment and facility requirements according to time schedules, locations, and source of support.

(9) Instrumentation and Data Collection. Delineate the method of data collection, specifying whether automatic or manual, and indicate where it will be performed. Include requirements for special instrumentation needs and data handling. Refer to standard data collection forms, if applicable, or forms specially prepared for this purpose.

(10) Date reduction. Indicate methods of processing and the form in which the date will be presented; specify requirements for equipments such as digital computers, oscillograph scanners, etc., needed for data reduction; express in hours the computer time required, and list requirements for any special computer programs.

(11) Schedules. Arrange test schedules into a logical sequence according to objectives, milestones, and target dates. Schedule realistic and coordinated test dates.

(12) Test Analysis and Reports. Indicate the person(s) who will analyze the test results; also state the type and frequency of reports required and to whom they will be sent.

b. Test Procedure

(1) Installation and Evaluation. Prescribe checks of installation plans to ensure proper workmanship. Include checks for placement in accordance with the plan, adequate foundations and equipment mounting, proper cable and wiring procedures, and correct wire termination.

(2) Unit Tests. In general, individual equipment tests should be made in accordance with the procedures prescribed in the equipment instruction books (NAVSHIPS, TOs, TMs, etc.) for initial setup. These tests are not intended to duplicate, substitute or modify any in-plant acceptance tests required by procurement contracts. The tests are confined to the equipment itself and may require the use of either built-in or external test equipment. Test results showing a level of performance below

standard shall be regarded as deficient. Antennas will require the equivalent of equipment tests. Refer to NAVELEX 0101,104 — "HF Radio Antenna Systems" for test parameters. Testing of microwave, tropospheric scatter and other systems will be parts of criteria books yet to be issued.

(3) Operational Test. Prescribe the performance testing of the equipments as a complete entity over a specific time period for the purpose of demonstrating the ability to fulfill operational requirements. Performance of this test may require the introduction of a wide range of simulated operational situations to demonstrate fully the compatibility and capabilities of the subsystem. In general, system tests should include all of the equipments and interconnections normally comprising a system, from the site input to the site output. The intent of system tests is to verify the compatibility of equipments comprising a system. If possible, include equipments from each station site in overall system tests.

(4) Design Verification. Prescribe the types and amount of design verification. The major points to be included are:

a. that equipments are provided in accordance with the installation plans.

b. that "as-built" drawings and manuals, spare parts, special tools, and special test equipment are on hand.

c. that adequate on-the-job training is provided for operator and maintenance personnel.

11.3 PERIODIC SYSTEM TESTS

In the past, the Naval Electronic Systems Command has made periodic equipment inspections within the communications stations. These inspections were found to be of marginal utility in improving the communications capabilities of the station inspected. Consequently, the equipment-by-equipment inspection is being replaced by a communications capability test. Such tests will not only be conducted biennially at each communications station, but also when major changes in equipment have been made.

The communications capability test measures the degree of distortion introduced into a discrete information sample while it is being processed at a single station. This test covers all the equipment from the introduction device to the HF propagation path and from the HF propagation path to the end instrument. The result of the test is an accurate error count of the data sample after it has passed through the receive or transmit capability of the station. This capability test is performed for both analog and digital circuits. The test analysis is based on the required circuit speed (data baud rate) and upon the amount of distortion introduced into the sample as it flows through the station.

To perform this test, NAVELEX provides a team of experts equipped with special test equipment. The test is designed to disrupt as little as possible the normal communications actions of the station. For example, the equipment is not disabled, and while individual circuits are being tested the communications normally conducted by that circuit are shifted to standby equipment. As the test methods are perfected, it is envisioned that test equipment may be installed within a station to provide a self-testing capability that can be used after preventive maintenance action and when system degradation is suspected.

11. 3. 1 Test Procedure

The test procedure developed to date is restricted to digital and teletype circuits. A discrete 20, 000-baud test message is processed through both the send and receive sides of each circuit of the communications station. The test message is produced by a pattern generator that can be set for various precise baud speed rates. The 20,000 - baud message is sent through a system at the rated circuit capacity. Then the message speed is increased until 50 percent above the rated circuit capacity is attained.

The send side of the circuit is tested by introducing the test message at the DC patch-board nearest the send device and measuring the output with a test stand located at the transmitter site (figure 11-1). The test stand employed at the transmitter site consists of a radio receiver accurately controlled with a frequency standard, a demodulator, and an error count detector that is set to evaluate accurately the received signal for distortion and total error count. The receive side of the circuit is tested in a similar manner; the test message is inserted at the receiver site, and the results are measured at the DC patch-board nearest the end equipment (figure 11-2). The transmitter used to couple the test message to the receive antenna is also carefully controlled in frequency and stability.

11. 3. 2 Test Results

Test data indicate that the communications capability test can be used effectively to evaluate the circuits of a station. Figure 11-3 is a graph of the test results of a 3-kHz bandwidth receive system employing a VFCT terminal. The history of the test follows.

A communications station was asked to allow the communications capability test to be made on a receive system that was considered to be in excellent condition both from maintenance and operational standpoints. The test results, curve 1 of figure 11-3, show that only 82 percent of the digital channels of the VFCT system would pass errorless information at the 75-baud rate. The test team asked the maintenance personnel to conduct a routine preventive maintenance check of the system and to perform every step of the procedure as prescribed by the manufacturer's maintenance manual for each equipment in the system. Upon completion of the maintenance actions, the communications capability test was again conducted, and curve number 2 of figure 11-3 was obtained. This curve indicates that all of the channels of the VFCT equipment were then capable of passing errorless traffic up to the 109-baud rate.

The communications capability tests have shown that frequency control and frequency accuracy of the transmitter and the VFCT equipment are major factors in passing digital and teletype traffic without introducing errors. The effect of frequency deviation of the transmitter during transmission of single-channel, frequency-shift-keying, 100-words per-minute teletype, using a frequency shift of ±425 Hz, is shown by figure 11-4. Frequency control and accuracy are even more critical in the VFCT equipment. Figure 11-5 shows the test results for an individual channel of the VFCT equipment employing a ±42.5-Hz center-frequency keying shift.

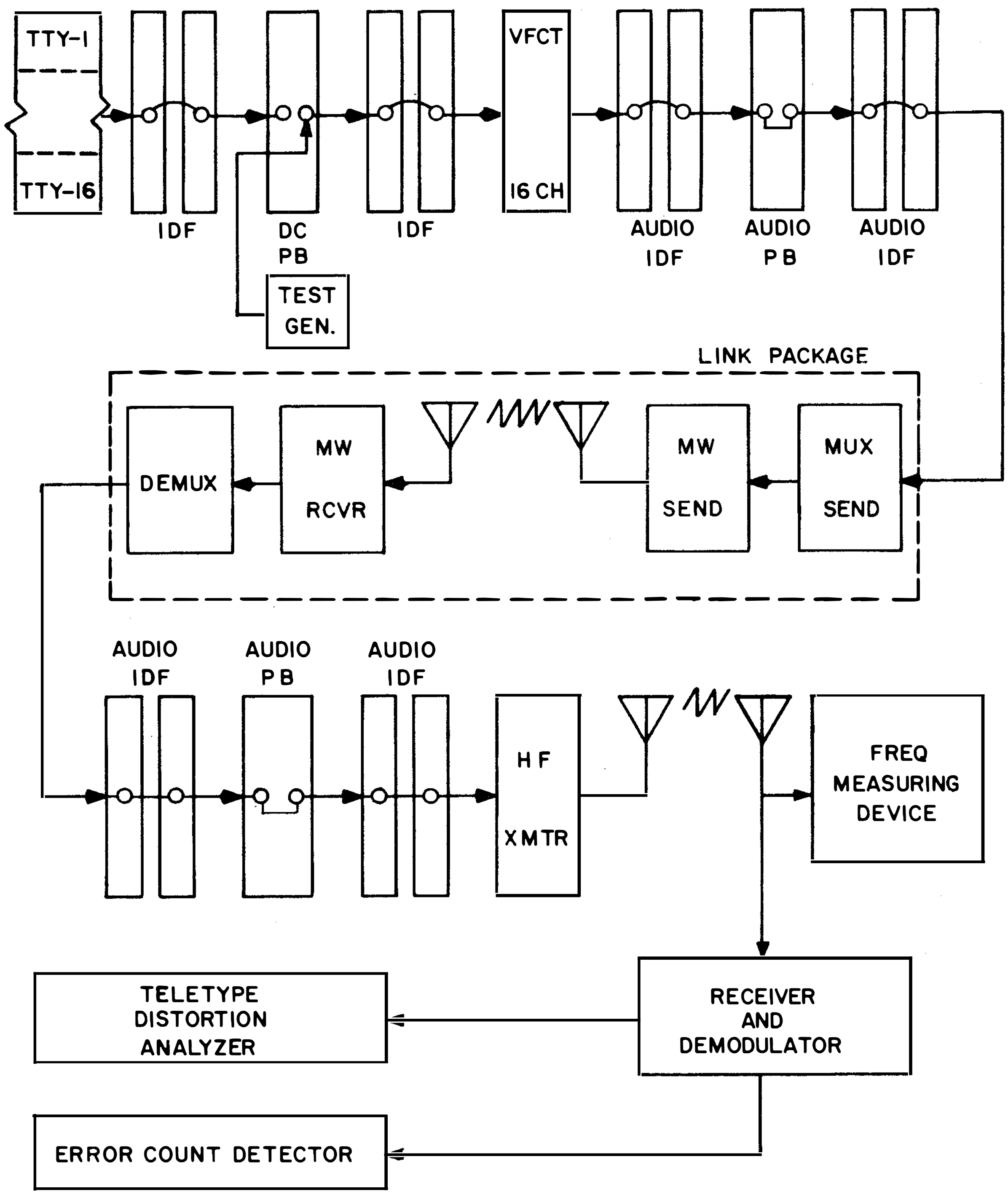


Figure 11-1. Typical Send Circuit Test

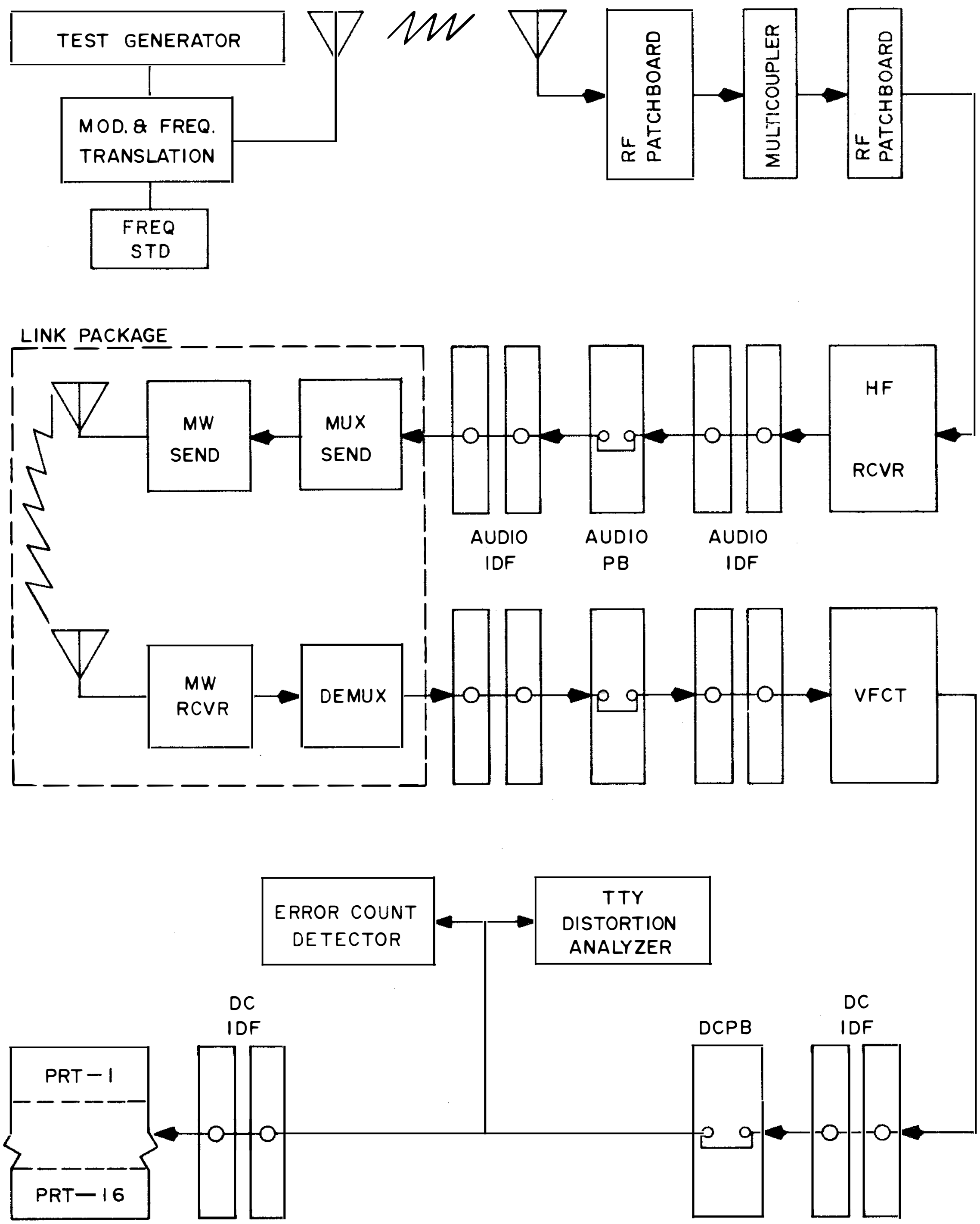


Figure 11-2. Typical Receive Circuit Test

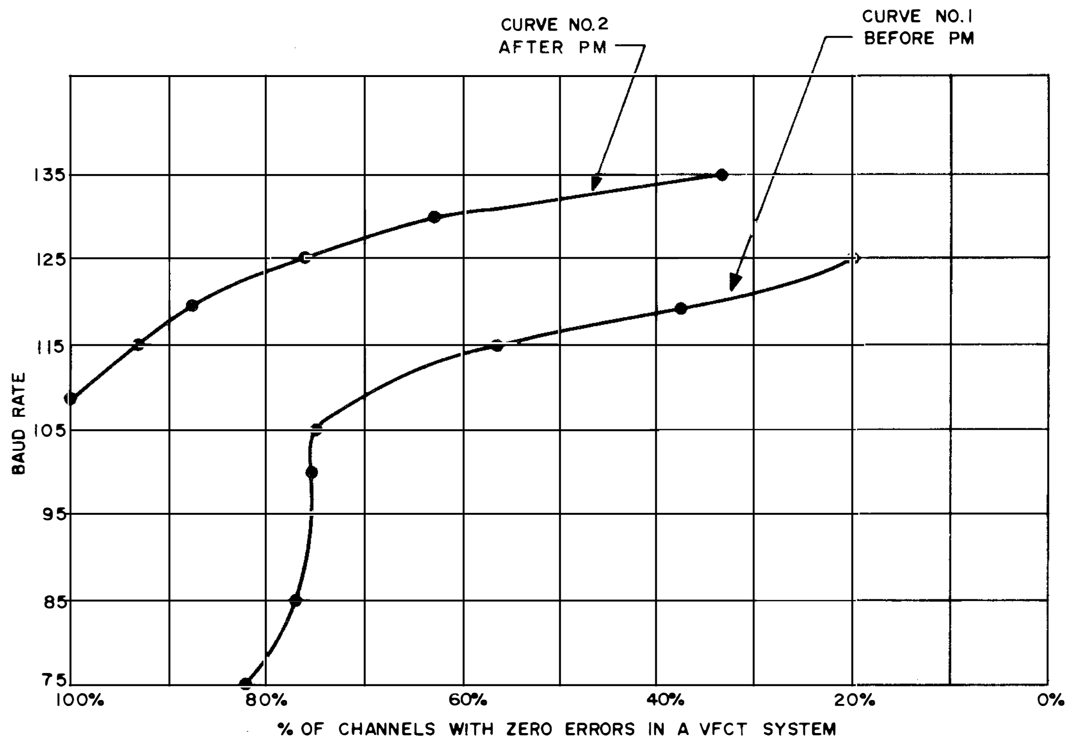


Figure 11-3. 3-kHz VFCT Receive System Test Results

The test results are being used to equate teletype circuit distortion to teletype character error rate. The graph of figure 11-6 has been developed through empirical test data, and it is also compatible with the DCS criteria for satisfactory teletype transmission of not more than one error in 10,000 transmitted characters. This graph can be used as an indication of circuit error rate as derived from the readings of teletype distortion analyzing equipment.

11.3.3 Test Analysis

Analysis of the test data is based on the error count observed for a 20,000-baud test message transmitted at various baud rates. Each circuit is then rated as follows:

Good - No errors observed at the 100-baud rate.

Marginal - Two errors or less at a baud rate of 100 and none at a baud rate of 75.

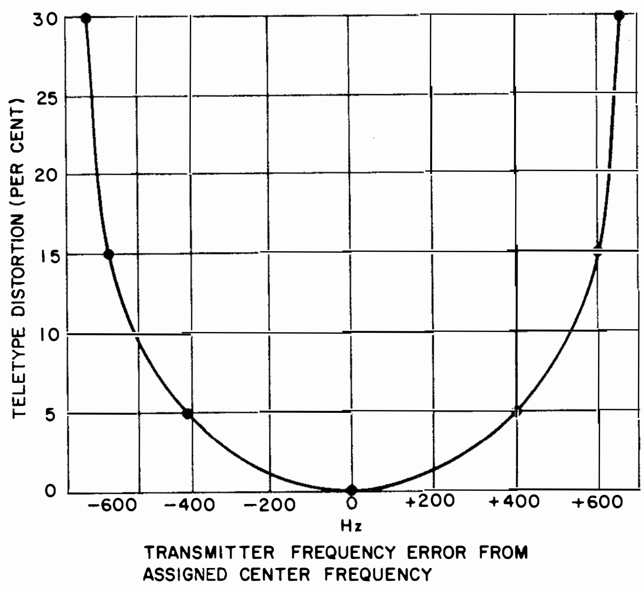


Figure 11-4. Single Channel FSK (±425 Hz) Transmission Test Data

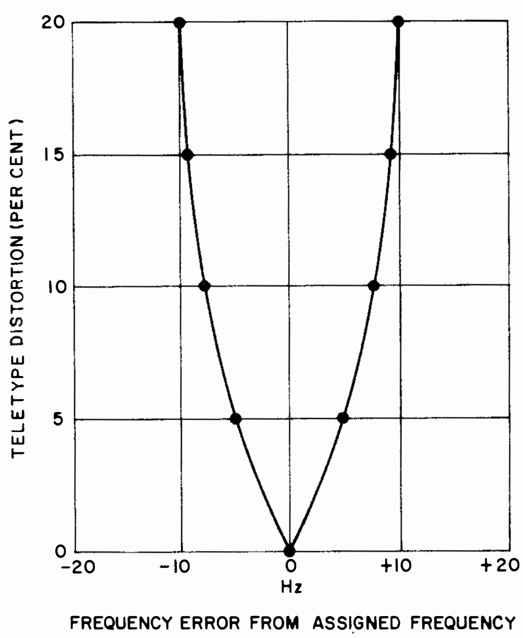


Figure 11-5. VFCT Channel Frequency Deviation Test Data

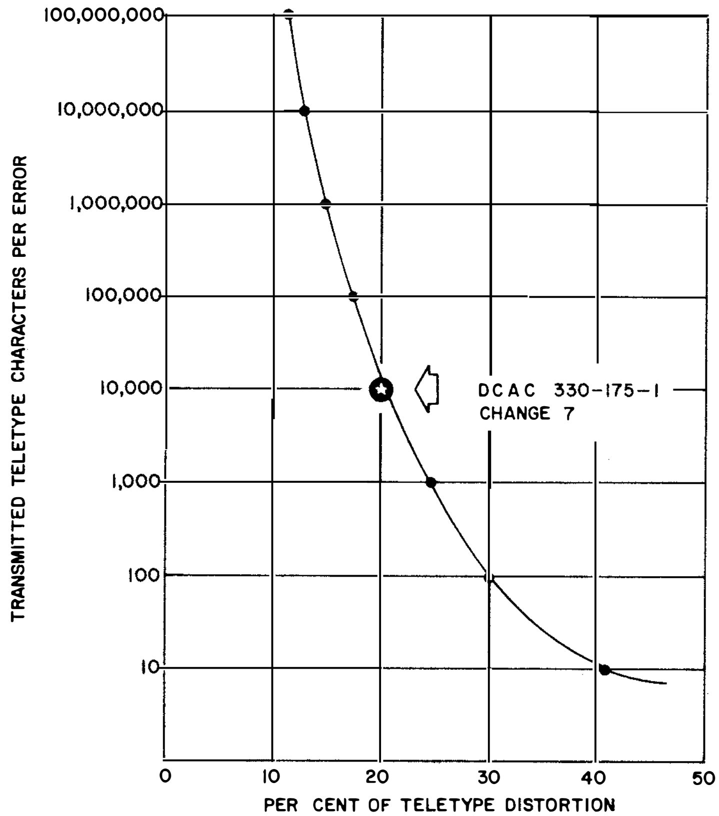


Figure 11-6. Teletype Distortion Rate Versus Error Rate

Satisfactory - No errors observed at the 75-baud rate.

Inoperable - More than one error at the 75-baud rate.

The limit of one error in a 20, 000-baud test message is based upon the DCA criteria for satisfactory medium speed digital transmission of not more than one error in 100, 000 transmitted bits.

Communications capability tests reveal that high error rates often exist without the knowledge of station personnel. The analysis of an overseas station subjected to this test is shown in table 11-1 and figure 11-7. Of the circuits tested, 16.2 percent were rated inoperable. Great variations were found in the capability of the VFCT equipment to pass errorless traffic. The degree of variation between VFCT systems is indicated by figures 11-8 and 11-9.

Table 11-1. Communications Station Technical Evaluation

	CIRCUIT QUALITY RATING			
	INOPERABLE	SATISFACTORY	MARGINAL	GOOD
Overall Circuit Analysis, 421 circuits (222 send, 199 receive). See curve one, figure 11-7.	16.2%	83.8%	30.6%	69.4%
Send Circuit Analysis, (222 send circuits). See curve two, figure 11-7.	13.0%	87.0%	33.8%	66.2%
Receive Circuit Analysis, (199 receive circuits). See curve three, figure 11-7.	19.5%	80.5%	27.0%	73.0%

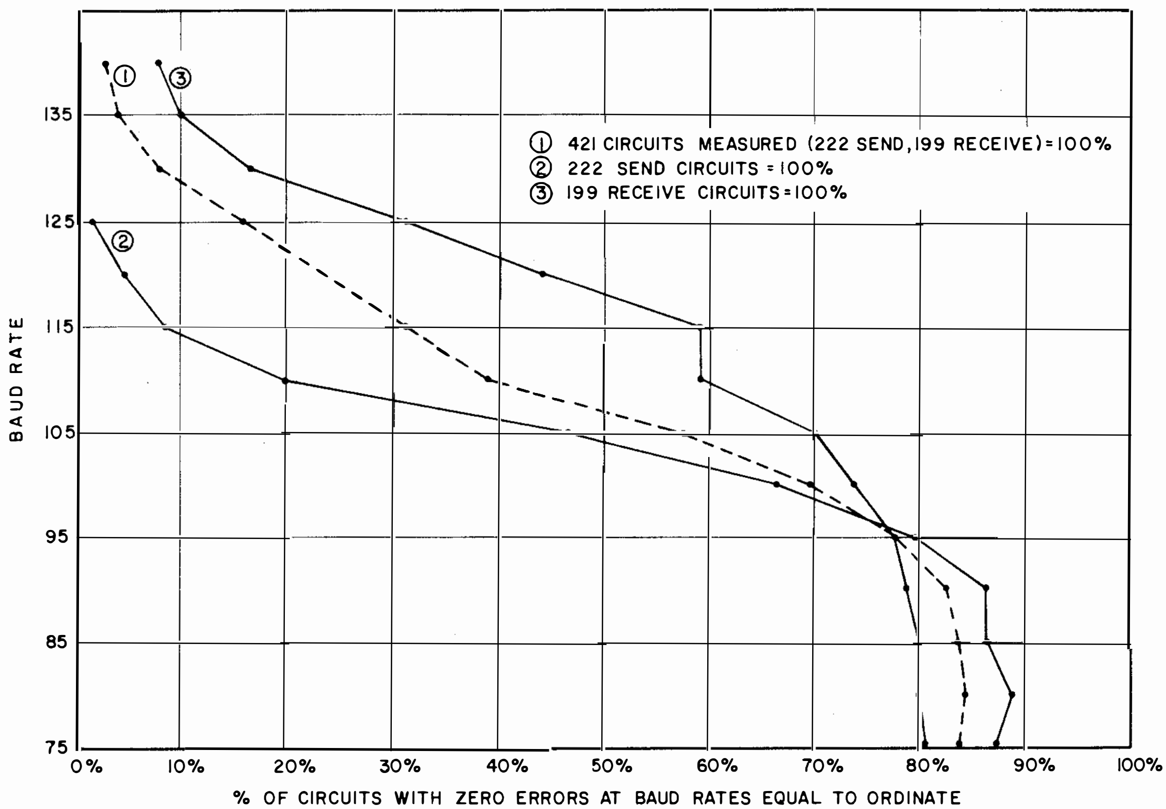


Figure 11-7. Circuit Evaluation

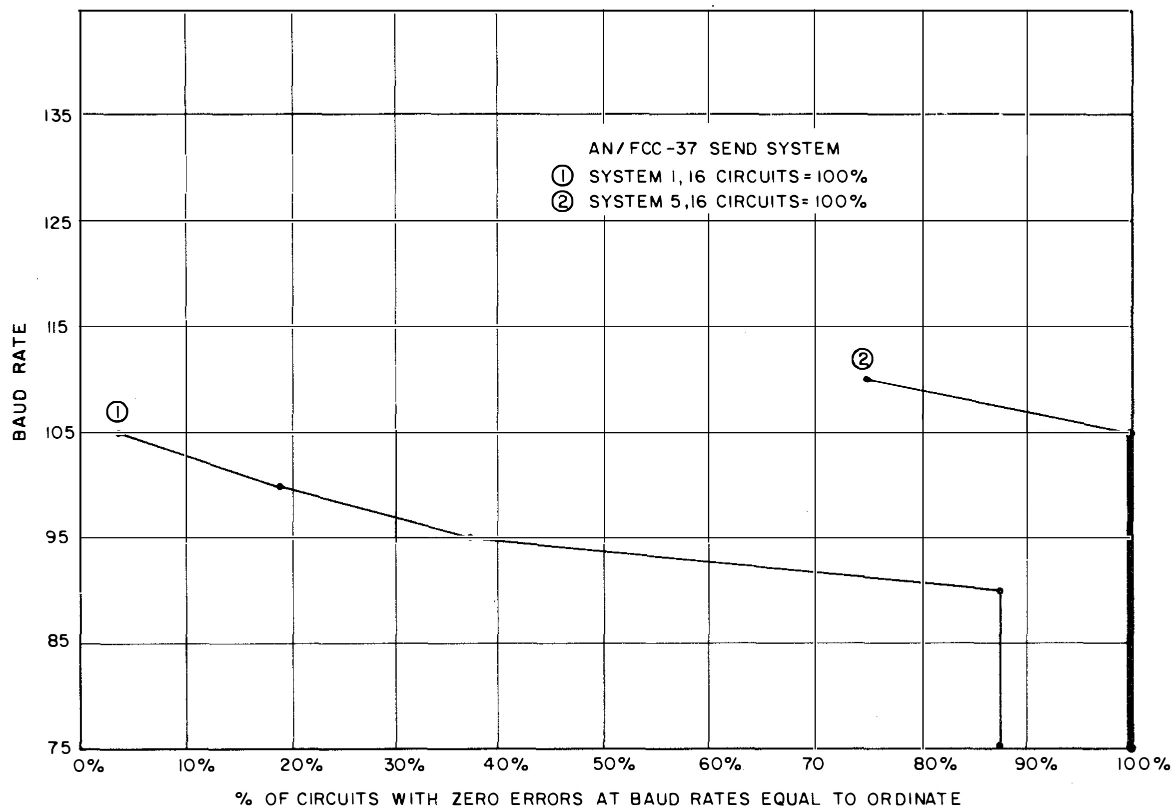


Figure 11-8. VFCT Send System Evaluation

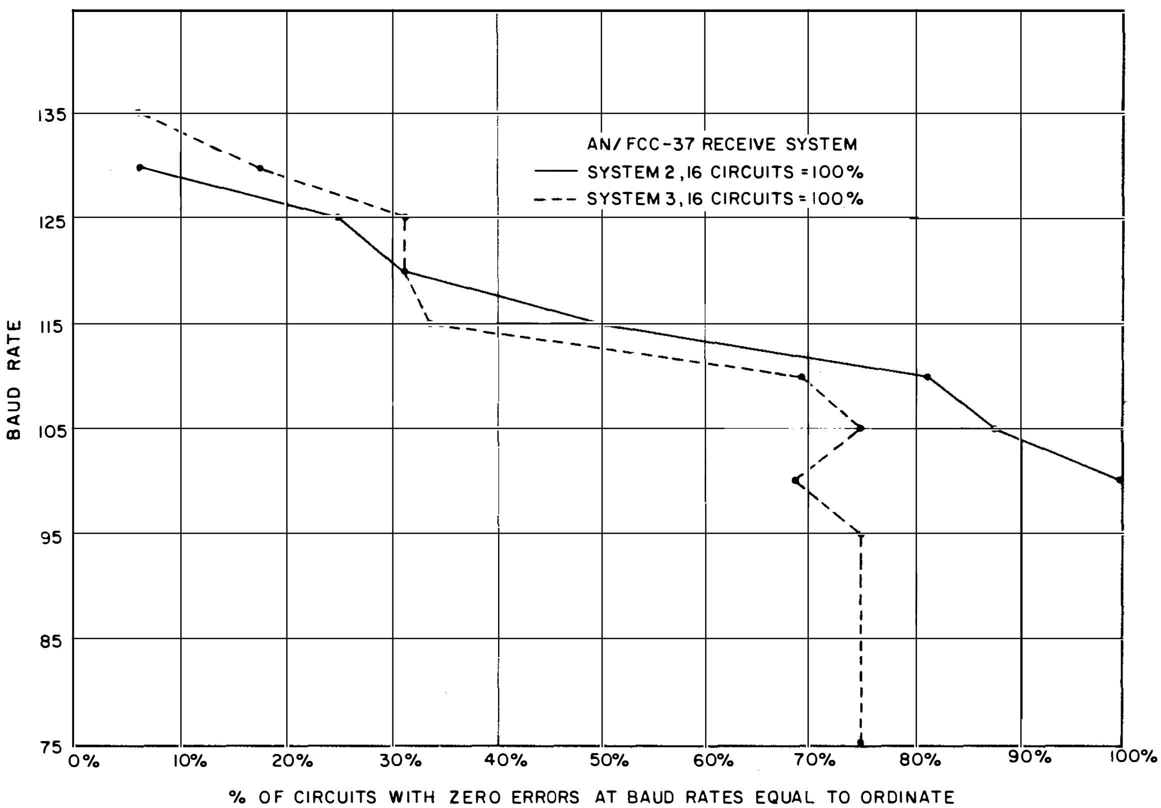


Figure 11-9. VFCT Receive System Evaluation

CHAPTER 12

COMMUNICATIONS ELECTRONIC GROUNDINGS

12.1 GENERAL GROUNDING AND BONDING CONSIDERATIONS

The major factors to be considered in the designing of an adequate grounding system are:

- Personnel protection
- Equipment protection
- Interference reduction
- RF efficiency
- Signal ground distribution
- Separation of the Red and Black signal ground

In deference to the above, several general rules should be followed when a ground system is designed.

a. Personnel protection must be provided by installing an electrical path between the equipment and the earth. The resistance of the path must be less than that of the human body and cannot be greater than 25 ohms to the earth.

b. Building protection against lightning must be provided by a low resistance electrical path between the metal structural portions of the building and the earth.

c. RF interference caused by standing waves on ground leads must be eliminated by keeping the ground leads to lengths less than that of one wavelength.

d. Where possible, a single ground system must be installed. A single ground system prevents potential differences between systems and reduces to a minimum the possible circulation of ground currents.

Methods and practices for establishing satisfactory grounds are discussed in the following sections of this chapter. Topics included are: establishing satisfactory earth ground points, interconnecting ground systems, ground point testing and ground system distribution.

12.2 FUSED METAL-TO-METAL GROUND SYSTEM JOINTS

During the planning phase particular emphasis should be placed on the construction of the ground system. Many undesirable short- and long-range effects can be stemmed, if not eliminated completely, by specifying the approved standards for fusing metal to metal. The approved standards are the results of continued research into the best possible methods of preserving the qualities of the specific metals selected for individual installations.

Investigation of the causes of ground joint failures has disclosed many undesirable effects. Some of these are:

- Brittle fractures
- Annealing of strength members
- Tempering of flexible members
- Crystalization of base metals
- Cold joints (incomplete fusing)
- Burnout (due to overcurrent)
- Acidic reaction deterioration
- Breaking due to overstress
- Corrosion rust
- Electrolysis between dissimilar metals
- Dirt and flux residue within the joint

The following practices and standards are to be adhered to, as applicable, within the design specifications.

a. All connections shall meet the quality requirements of specification MIL-B-7883.

b. When torch brazing is not practical, heavy section wires or rods being joined together or to heavy section structural members of the same kind or dissimilar metals can be joined by exothermic, fused cast-in-place alloys of the appropriate type.

c. Small diameter or thin section copper or copper-clad wires can be fused to steel or other dissimilar metals by brazing with alloys per Federal Specification QQ-S-561, Class 4, using flux per Federal Specification O-F-499.

d. Small diameter or thin section copper or copper-clad wires or rods can be fused to the same or other copper by brazing with alloys per Federal Specification QQ-S-561, Class 3, without flux.

e. Aluminum or aluminum alloys can be fused to the same or dissimilar metals by following the requirements of specification Mil-B-5087B(ASG).

12.3 EARTH GROUND CONNECTION

The choice of the earth ground point can range from a metallic underground piping system to electrodes installed in the ground especially for this purpose. The National Electrical Code, (1968), articles 250-81 through 250-84, establishes basic criteria for the earth ground connection point applicable to personnel safety only. The possible earth ground points, in order of preference, are as follows:

a. A metallic underground water piping system, either local or one that supplies a community, provided the building interior cold-water system is also bonded to one or more installed electrodes.

b. Other continuous metallic underground piping systems, exclusive of a gas service piping system.

c. The metal frame of a building if the frame is effectively grounded.

d. Installed electrodes.

Installed electrodes commonly in use at communications stations are described in the following subparagraphs. When electrodes are installed for the safety of personnel, the resistance between the electrodes and the earth is not to exceed 25 ohms. Continuous metallic underground water systems in general have a resistance to ground of less than 3 ohms; metal frames of buildings and local metallic underground systems usually have a resistance substantially below 25 ohms.

12.3.1 Driven Electrodes

Driven electrodes, or ground rods, are used for the earth ground connection where bedrock is beyond a depth of 10 feet. Since these electrodes are subject to the corrosive action of the earth, they should be made of copper-clad steel. These electrodes, available commercially in various lengths and diameters, can be joined together to extend their length (figure 12-1).

Generally, the depth of the electrode determines the resistance of the earth ground connection. Rods should be driven deep enough to reach the permanent moisture level of the earth whenever possible. Failure to reach this level may result not only in high resistance, but may cause large resistance variations during seasonal weather fluctuations.

12.3.2 Multiple Driven Electrodes

Several driven electrodes may be used to obtain a specified minimum ground connection resistance. When multiple driven electrodes are used, their upper ends are bonded together with No. 4 AWG bare copper wire.

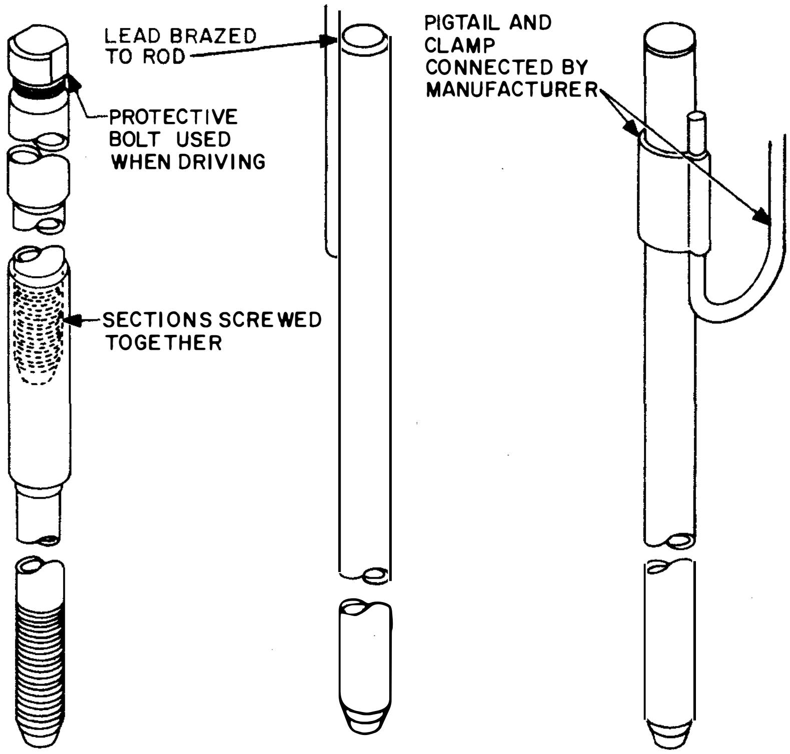


Figure 12-1. Grounding Rods

The resistance of the connection to the earth made by a driven electrode is distributed in a hemisphere of earth about the electrode. For this reason the direct reciprocal relationship for resistance in parallel is not obtained when multiple electrodes are driven. The hemisphere of one electrode will always tend to overlap that of the other. Figure 12-2 shows the amount of reduction of ground connection resistance to be gained by driving multiple electrodes spaced various distances apart. The separation between electrodes should be a minimum of 6 feet. As a general rule, multiple electrodes are spaced at 10 to 20 feet. With this configuration, the optimum ground connection is approached while practical considerations are satisfied.

The minimum ground resistance that can be obtained through the use of multiple electrodes depends upon the dimensions of the area available. Figure 12-3 shows the relationship between the conductance of a group of electrodes over a given area and the conductance of a single electrode. From this graph it can be seen that the maximum conductance possible with an unlimited number of electrodes in an area of 500 square feet is only 4.9 times the conductance of a single electrode. However, 10 electrodes equally spaced in this area would result in a conductance of 4.6 times that of a single electrode. Since this difference in conductance is not significant, a limited number of electrodes may be presumed practical for a given area. Figure 12-3 also shows that if 10 times the conductance of a single electrode is desired, the electrodes must be distributed over an area in excess of 2000 feet.

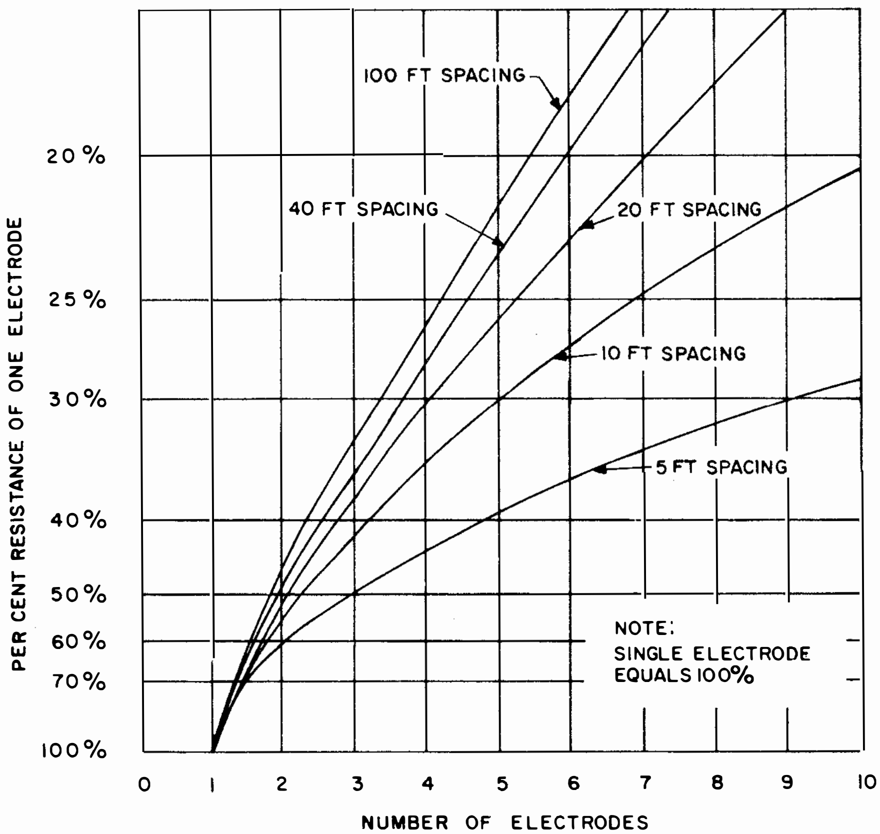


Figure 12-2. Comparative Resistance of Multiple Grounds

Figure 12-4 shows an acceptable plan for a system of driven electrodes used as the earth ground connection. The ground consists of seven 20-foot copper-clad rods driven into the earth in a radial pattern. Six rods are in a circle with the seventh rod driven in the center of the circle. Each outer rod is connected to the center rod by No. 4 AWG bare copper wire. One No. 4 AWG insulated wire connects the center rod of this ground rod array to the ground distribution system of the building.

12.3.3 Buried Plate Electrodes

Grounding plates are used when the physical configuration of the site prohibits use of more conventional ground point connections. These plates are sometimes used where immersion in water or damp soil is a practical grounding method. When grounding plates are used, each plate should present no less than two square feet of surface to the exterior soil.

The ground connection resistance of a grounding plate depends upon the overall dimensions of the plate. The variation of ground connection resistance with plate size is illustrated in figure 12-5, which is based on calculations for a circular plate in soil having uniform resistivity. This figure shows that quadrupling the size of the plate approximately halves the ground connection resistance. The

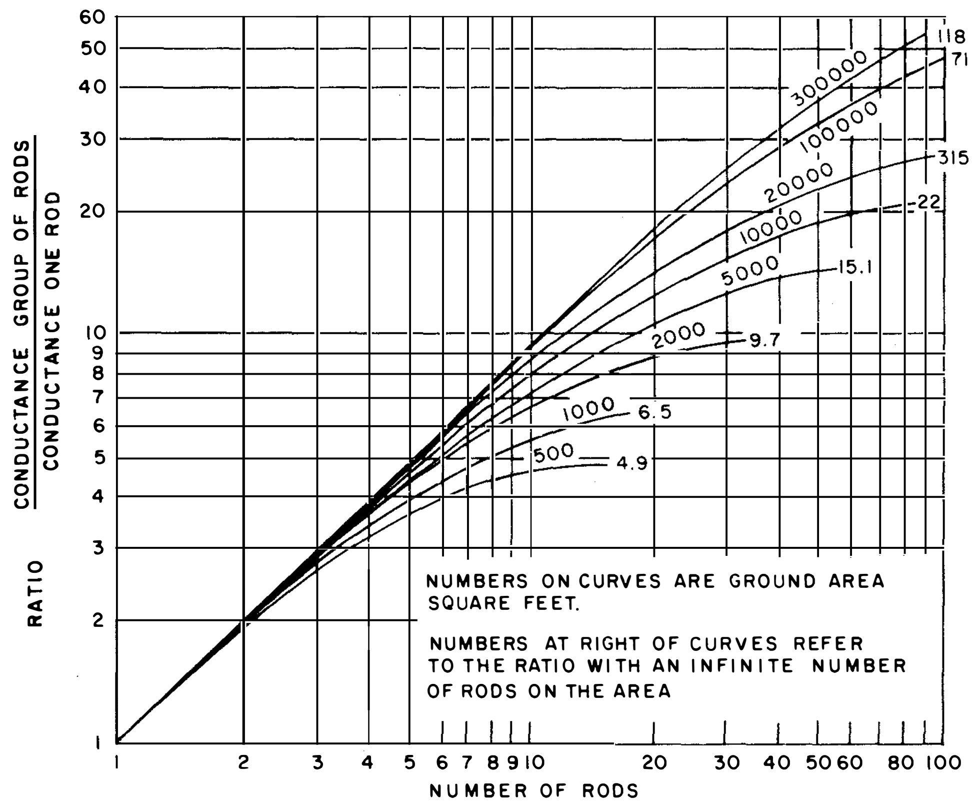


Figure 12-3. Conductance of Multiple Electrodes Versus Area

curve in figure 12-5 also shows that increasing the area of the plate beyond 25 to 30 square feet does not result in an appreciable decrease in ground connection resistance. This relationship is also valid for a rectangular plate, although the curve of figure 12-5 should be taken as an indication of the relationship, not as a check on it. When a large surface area is required, the use of two or more smaller plates will facilitate installation. The total surface area that the plates present to the earth governs the amount of resistance with respect to earth; no electrical parallel resistance relationship is obtained by the combination of plates. Grounding plates are composed of Everdur (alloy No. 1010), an alloy consisting of approximately 96 percent copper, 3 percent silicon, and 1 percent manganese. This alloy has a conductivitv approaching that of copper and a high resistance to corrosive or oxidizing elements. The connector between the plates and from the plate to the station ground distribution system is a strap 12 inches wide and 0.25 inch thick.

The Test Equipment Standards Laboratory, U.S. Navy Repair Facility, San Diego, uses an Everdur plate as the earth ground point. See figure 12-6. The plate is buried 10 feet deep with one foot of sand above and below the plate. The sand is dampened by sea water at high tide. A capped pipe, which protrudes above the ground, is used for supplementary moistening.

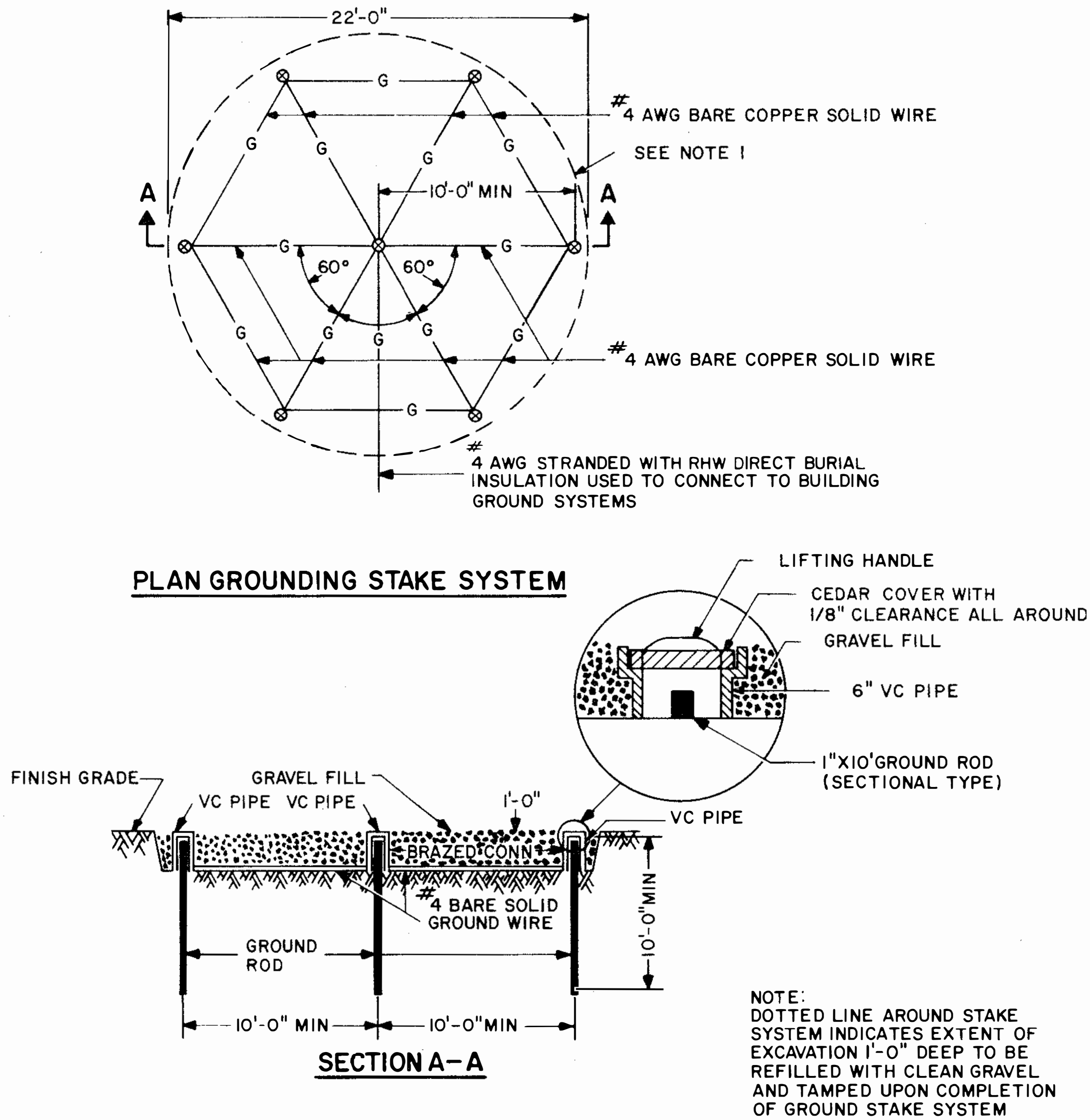


Figure 12-4. Multiple Driven Electrode Ground Plan

12.4 EARTH GROUND POINT TESTING

It is difficult to test an established earth ground point, and, if undertaken, the results are of questionable value. The effectiveness of an existing earth ground point is best determined by a review of the engineering and installation practices used to install the ground and by careful inspection to ensure the integrity of all welds used to bond the ground point to the grounding system.

Standard methods of determining the effectiveness of an earth ground point are based upon the establishment of reference grounds for the taking of test data. Each reference ground established must have a resistance to ground that is less than 10 times that of the earth ground point under test. If the test is to be effective, the

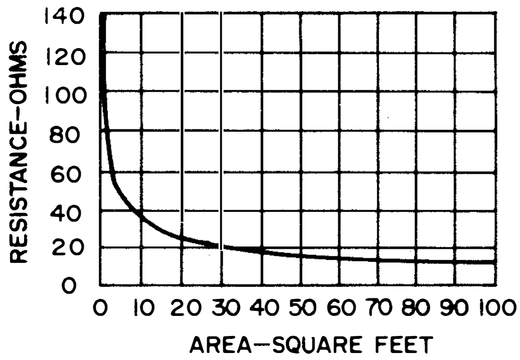


Figure 12-5. Resistance as a Factor of Contact Area for Circular Plate

earth ground point must be isolated from all grounding systems. NAVFAC DM-4 — "Electrical Engineering" recommends the three-electrode method or the fall-of-potential method for measuring the resistance of an installed ground.

12.4.1 Three-Electrode Test Method

Driven and plate electrodes may be tested for earth connection effectiveness using the "three-electrode method." This method, illustrated by figure 12-7, utilizes two reference ground points in addition to the earth ground point under test. A standard megger is used to determine the resistance in ohms between each pair of ground points. The resistance in ohms of the ground point under test is then determined from the following equation:

$$R_a = \frac{(R_{a,b}) + (R_{a,c}) - (R_{b,c})}{2} \qquad (12\text{-}1)$$

R_a = Ground connection resistance of the rod or plate under test.

$R_{a,b}$ = Measured resistance between ground points a and b.

$R_{a,c}$ = Measured resistance between ground points a and c.

$R_{b,c}$ = Measured resistance between ground points b and c.

This test is performed by driving rods for the reference ground points four feet into the earth to form a 100-foot equilateral triangle with the ground connection under test. The ground points are designated as shown in figure 12-7. The resistance between a and b, a and c, and b and c is then measured and the resistance of the ground point under test is calculated from equation 12-1.

12.4.2 Fall-of-Potential Test Method

Figure 12-8 illustrates the fall-of-potential test method which involves the use of an ungrounded alternating current power source to circulate a constant current between the ground mat under test and a fixed reference ground probe G_1. The test

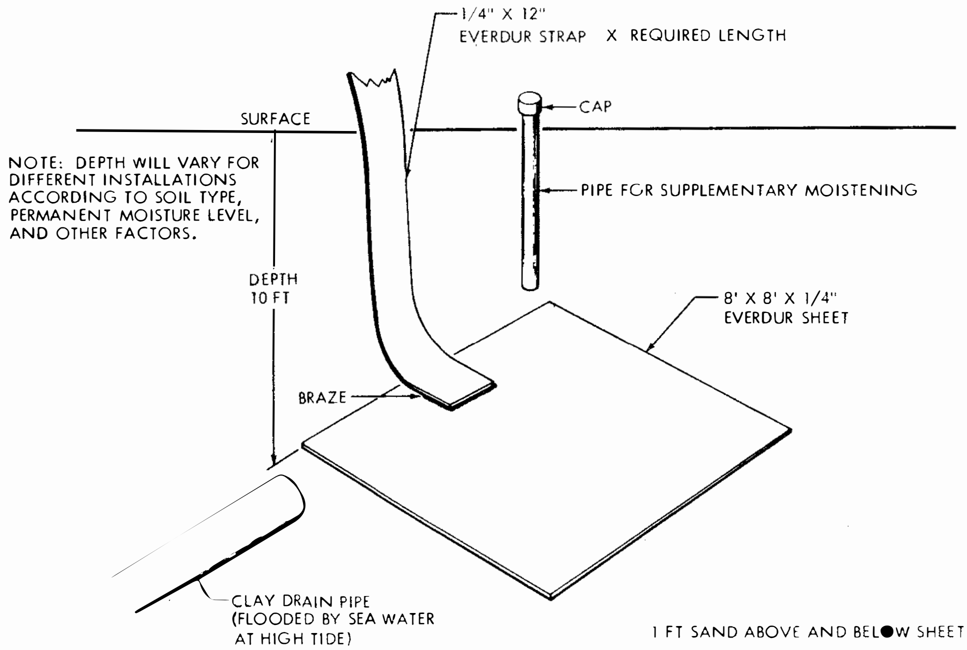


Figure 12-6. Everdur Ground Installation at USNRF, San Diego

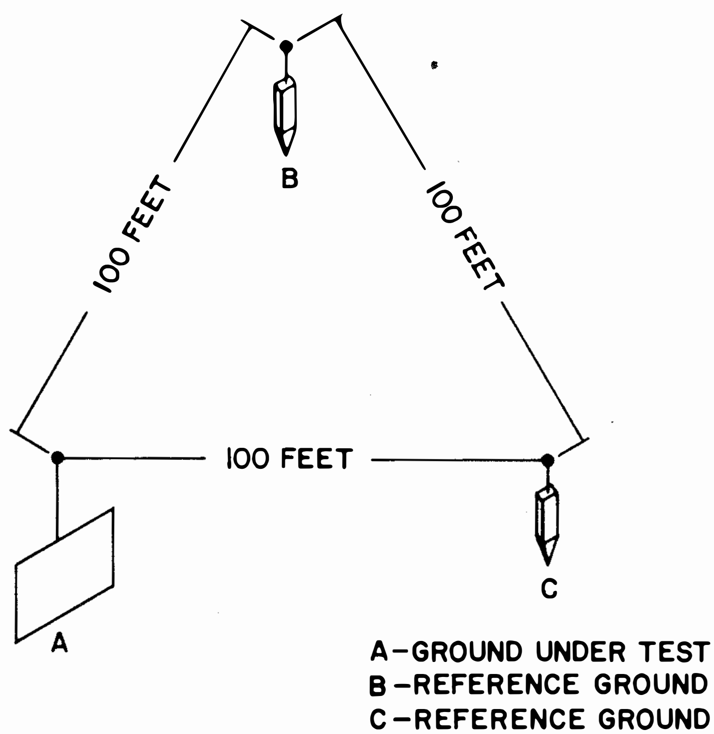


Figure 12-7. Three-Electrode Method of Measuring Resistance of Earth Ground Points

is conducted with the assumption that there is negligible resistance from fixed ground probe G_1 to the area of the ground mat and that the resistance measured is the contact resistance between the mat and the earth in the vicinity of the mat. In the fall-of-potential method a constant current (set by the adjustment of the variable resistance, figure 12-8) is passed between current return electrode G_1 and the ground mat under test. The potential electrode P is placed midway between the current source, and a voltmeter is connected between the potential electrode and the ground mat. The resistance R, of the ground mat can be computed from Ohms law:

$$R = \frac{E}{I} \qquad (12\text{-}2)$$

The test is similar to measuring the IR drop across a resistor, the resistor in this case being the contact resistance between the mat and the earth in the vicinity of the mat. Success of the method depends upon a low-resistance ground path between the ground mat and probe P.

In this test, ground stakes are driven and connected to meters and the power source as indicated by figure 12-8. The current and length of instrumentation leads constitute hazards to personnel; therefore, this method is not recommended unless the installation of a facility is in the planning stage or it can be otherwise justified. The voltmeter is connected between the ground mat terminal and probe P. The current is adjusted to one or more amperes to produce a center-scale reading on the voltmeter. This current must sustain throughout the test, but no further adjustment should be required unless the line voltage changes. Probe P is then moved from position to position along a path in a straight line between fixed point G_1 and the ground mat being tested, taking care to ensure that the probe is driven to the same depth at each position. A voltage reading is taken at each position of P and the current reading is checked to ensure that it is at the value previously set. The constant voltage reading and the current which produces the voltage are substituted into equation 12-2 to determine the resistance to ground of the mat being tested. In order for the results of this test to be meaningful the voltage reading for all positions of probe P must be the same over about two-thirds of the distance between the ground mat and G_1. If a constant voltage cannot be maintained with a constant current over about two-thirds of the distance, results might be improved by driving stakes P and G_1 further into the ground. If erratic results persist, other ground test methods should be employed.

12.5 IMPROVING EARTH GROUND POINT EFFICIENCY

If the earth ground point fails to meet a specified minimum resistance to ground it may be improved by use of deep-driven or multiple electrodes, or by chemical treatment of the earth surrounding the ground point.

12.5.1 Deep-driven Electrodes

Increasing the depth of the electrode is the simplest and most effective means of reducing ground connection resistance. Figure 12-9 shows the improvement that may be expected from an increase in electrode depth. The major limiting factor to applying this method is that rock may be encountered at greater depths in the earth.

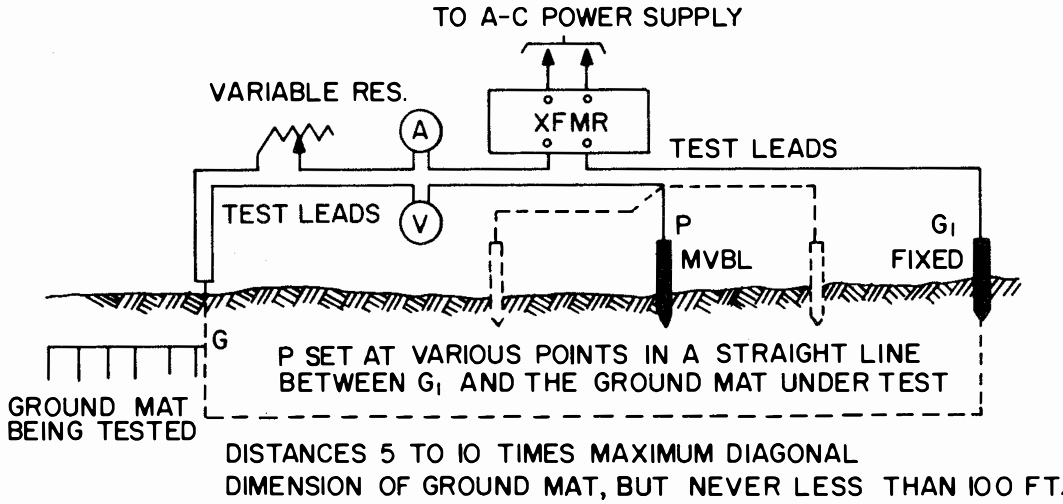


Figure 12-8. Fall-of-Potential Test Method

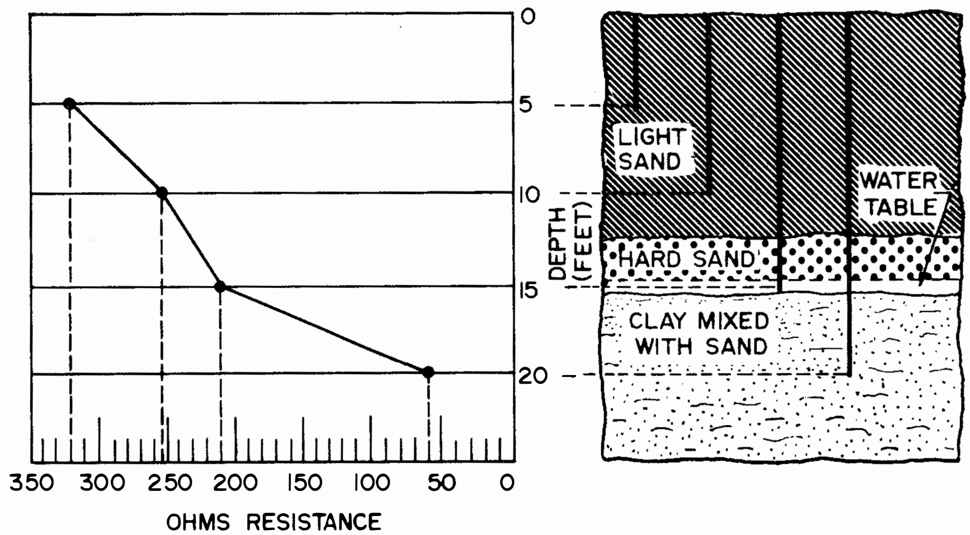


Figure 12-9. Electrode Depth Resistance

12.5.2 Multiple Electrodes

Multiple electrodes connected in parallel will tend to reduce the resistance of an earth ground connection. Refer to paragraph 12.3.2 for the procedures for using multiple driven electrodes.

12.5.3 Chemical Treatment

Where it is not feasible to use deep-driven or multiple electrodes, chemical treatment of the earth surrounding the electrode is an effective means of lowering ground connection resistance. Chemical treatment may also be used where plates are employed. An added advantage of this method is that the chemicals reduce seasonal variations in ground connection resistance caused by rainfall and lower the freezing point of the surrounding soil.

Several substances are used to reduce the resistivity of the soil immediately surrounding the electrode. The better known are:

Magnesium sulfate ($MgSO_4$) - epsom salts

Copper sulfate ($CuSO_4$) - blue vitriol

Calcium chloride ($CaCl_2$)

Sodium chloride (NaCl) - common salt

Potassium nitrate (KNO_3) - saltpeter

Magnesium sulfate is most frequently used, since it combines low cost with high electrical conductivity and low corrosive effect. The initial effectiveness of chemical treatment is greatest where soil is somewhat porous, because the solution permeates a considerable volume of earth, which results in increasing the effectiveness of the electrode. In compact soil the initial chemical treatment is not as effective as in porous soil because the solution tends to remain where placed for a longer period of time. It is necessary to use initially between 40 and 90 pounds of the chemical to retain the effectiveness of the ground for 2 or 3 years. Each replenishment of the chemical will extend its effectiveness for a longer period so that future treatments will be needed less and less frequently.

12.6 GROUND DISTRIBUTION SYSTEMS

12.6.1 AC Protective Ground

An AC protective ground distribution system is required to safeguard life and equipment. Such a system provides an electrical connection to the earth ground point for the protection of personnel and equipment from AC power potentials, lightning hazards, and electrical circuit failures. In this system a ground bus interconnects all equipment chassis; equipment cabinets and racks; all ferrous shields and covers; all conduits, raceways, cellular flooring, cable racks, and superstructures; ferrous shields of cables and transformers; and the protective ground of local telephone systems. The ground bus is normally composed of the metal-to-metal contact of ferrous conduit installed in the AC power distribution system. The integrity of the AC protective ground system is assured by running an additional unbroken, insulated, green wire with the AC power feeders that supply the equipments. This wire, which is connected between the case of the equipment and the case of the power panel that supplies the equipment, is designated the green-wire protective ground feeder. The green-wire protective ground feeder is required even though the AC power feeders are supported in metallic conduit or other supports.

NOTE

The green-wire protective ground feeder does not replace the color-coded white or natural gray wire used for the return side of all AC power feeders.

12.6.2 Signal Ground

The signal ground distribution system is used as a zero reference level between communications circuits and as an electrical connection to the earth ground point. The primary purpose for the signal ground distribution system is to provide the highest signal-to-noise ratio possible on the signal circuits between equipments. The governing criteria for a signal ground system are contained in the latest issue of NAVELEX Instruction 011120.1. The following general requirements must be met by the design of a signal ground system.

a. The signal ground system may have its own ground connection point. NAVELEX Instruction 011120.1 specifies the type of ground connection to be used for both large and small systems.

b. Separate ground distribution systems are required for Red and Black signal grounds. NAVELEX Instruction 011120.1 specifies when and where these two systems are to be interconnected. A Red signal ground distribution system connects the ground side of all signal loops and the nonferrous shields of all signal and signal control cables that may carry plain-text classified information to the earth ground point. A Black signal ground distribution system connects the ground side of all signal loops and nonferrous shields of all signal and control cables that may carry unclassified and encrypted information to the earth ground point.

12.6.3 Security Fence Ground

A security fence at a transmitter site may require a grounding system to insure personnel safety. Grounding of fencing may also be required at various sites to prevent reradiation of signals. An approved method of grounding a fence is shown in figure 12-10. When a gate is incorporated as part of the fence its hinges must be bonded with flexible No. 8 AWG copper wire. These wires are to be connected to the gate post and the frame of the gate using exothermic welding or approved pressure connectors.

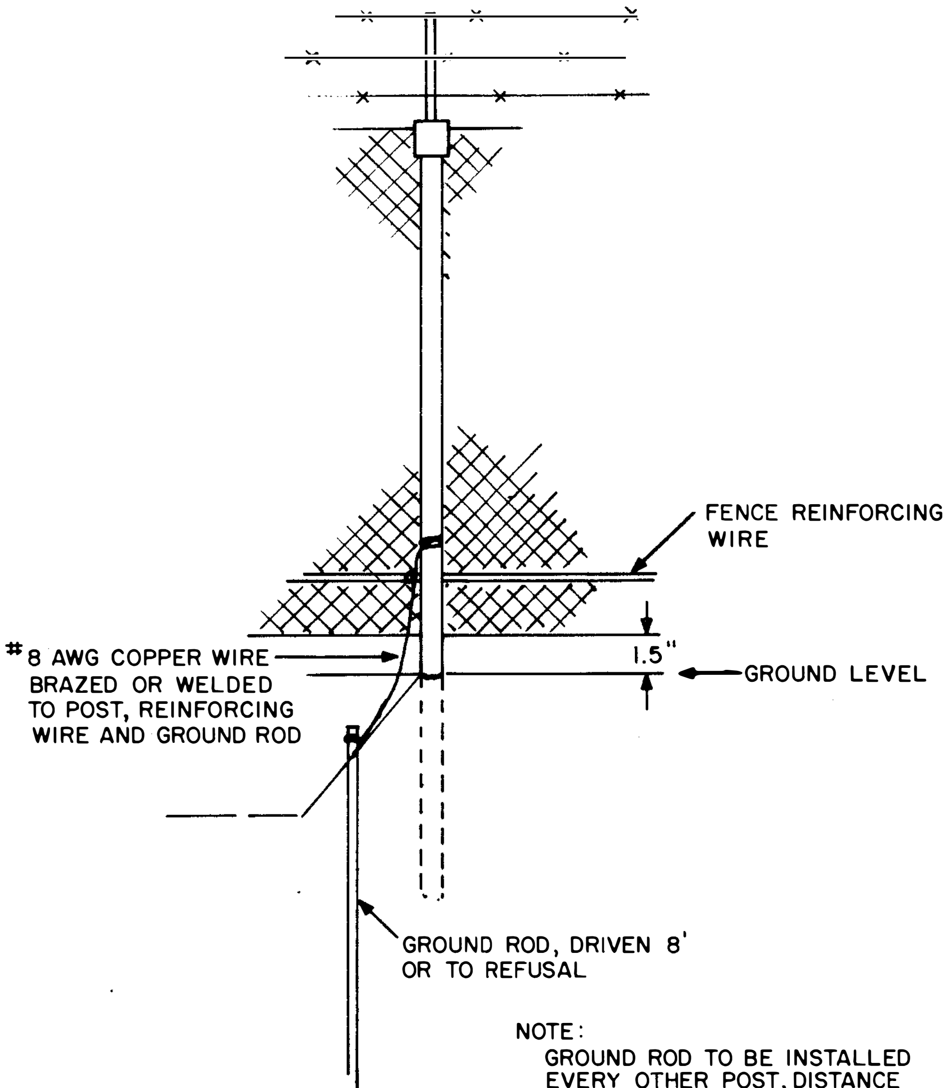


Figure 12-10. Typical Fence Grounding Plan

CHAPTER 13

TRANSPORTABLE TRANSMITTER/RECEIVER (TR) STATIONS

13.1 GENERAL

Transportable stations can be used as substitutes for permanent stations when (1) national policy prohibits construction of permanent facilities and (2) time does not permit construction of permanent facilities. Also, they can be used to replace disabled facilities or to augment existing ones. Transportable equipment falls into two major classes: tactical and semi-transportable. Tactical equipment is pre-packaged and designed for quick placement and short-term use. Semi-transportable equipment is designed to provide a fixed station capability for long-term use and to make feasible the recovery of a major portion of a station's total assets for possible redeployment. The use of semi-transportable equipment also makes possible a complete station check-out prior to shipment to the user location.

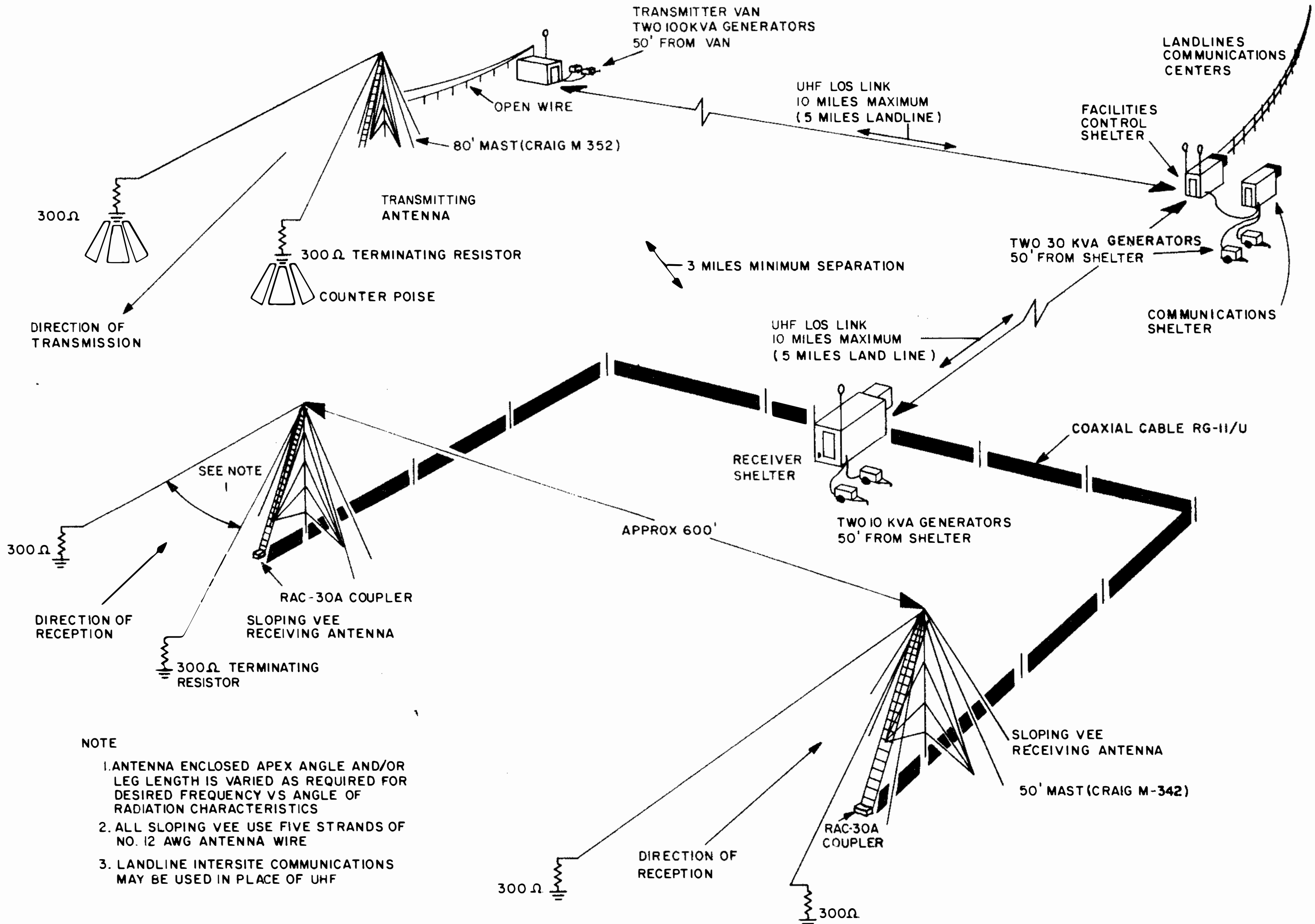
13.2 TACTICAL TRANSPORTABLE EQUIPMENT

Van-type enclosures outfitted with the necessary equipment required for specific communications applications are maintained in the government inventory for special purpose short-term tactical use. Volume II of DCAC 370-185-1 — "DCS Applications Engineering Manual " describes the various sets and the general installation requirements for each. Each set is self-sufficient for communications purposes but does not in itself provide for personnel support. A typical tactical equipment set is the AN/TSC-18, a 2- to 28-MHz, 40-kW independent sideband radio facility, complete with antennas and transmission lines.

The AN/TSC-18 system, illustrated in figure 13-1, includes three facilities: transmitting (one van), receiving (one shelter), and communication center (two shelters). These facilities are interconnected by a UHF link. The control and communications shelters are collocated and are within 10 miles (line of sight) of both the transmitter and receiver sites. The system characteristics are completely compatible with the DCS HF radio reference circuit described in chapter 2. Size and weight of the major components of a system are given in table 13-1.

The location of the AN/TSC-18 system depends upon the tactical situation, antenna siting considerations, and local terrain. Three sites are required: one for the transmitter van (approximately a 5-acre rectangular plot with 500 feet cleared in the direction of transmission), one for the receiver shelter (approximately a 10-acre square plot), and one for the facilities control and the communications shelters (approximately 2 acres). Where possible, the three ground sites should be level, dry and with good drainage. The following factors are pertinent to the siting and antenna layout for this system:

a. Radio signals are absorbed and sometimes reflected by nearby obstructions. Transmission and reception are best over water or level ground.



NOTE

1. ANTENNA ENCLOSED APEX ANGLE AND/OR LEG LENGTH IS VARIED AS REQUIRED FOR DESIRED FREQUENCY VS ANGLE OF RADIATION CHARACTERISTICS
2. ALL SLOPING VEE USE FIVE STRANDS OF NO. 12 AWG ANTENNA WIRE
3. LANDLINE INTERSITE COMMUNICATIONS MAY BE USED IN PLACE OF UHF

Figure 13-1. AN/TSC-18 System Facility and Antenna Plan

Table 13-1. Size and Weight of AN/TSC-18 System Components

COMPONENT	SIZE AND WEIGHT
Transmitter Van	Van: Model M373A2C Length 366' width 96", height 132" Weight: 22,700 lb fully loaded, 11,000 lb empty
Receiver Shelter	Shelter: S-141/G (Modified) Length 146", width 84", height 84" Weight: 7100 lb fully loaded, 1550 lb empty
Facilities Control Shelter	Shelter: S-141/G (Modified) Length 146", width 84", height 84" Weight: 5800 lb fully loaded, 1550 lb empty
Communications Shelter	Shelter: S-141/G (Modified) Length 146", width 84", height 84" Weight: 6800 lb fully loaded, 1550 lb empty

b. The site selected for the receiver shelter must have sufficient space for diversity receiving antennas. The receiving antennas are located on either side of the shelter a minimum of 5 wavelengths apart at the lowest operating frequency.

c. There should be at least a 3-mile separation between the receiver shelter and the transmitter van.

13.3 SEMI-TRANSPORTABLE EQUIPMENT

Semi-transportable stations, now in use at various overseas locations, were designed and built to fulfill the known fixed station communications requirement for these locations. Each station consists of groups of shelters, each shelter designed with equipment installed so that, when the shelters are interconnected, the composite group satisfies the entire communications requirement. Thus the long-term, sustained, high-capacity, long-haul, fixed-plant characteristics required of a communications station are provided, housed in transportable communications modules. The modules contain standard, presently available reception, transmission, switching, and technical control equipment along with all necessary facilities for personnel and equipment support. This modular concept permits the rapid creation, augmentation, or tear-down of a communications station in building-block fashion.

The modules are designed and arranged to conform to the requirements for separate functional areas defined by COMNAVCOMM INST 2300.3 dated 23 July 1969. Figures 13-2 and 13-3 show typical site plans for semi-transportable stations; the individual modules are identified by table 13-2. Figures 13-4 and 13-5 show typical equipment placement within the shelters and figures 13-6 through 13-8 are photographs of portions of the AN/TSC-35 semi-transportable communications system.

13.3.1 Typical Container Construction

The basic container used in the construction of these stations is similar to a Fruehauf van measuring 40 feet long, 10 feet wide and 9.5 feet high. The containers are made of structural steel framing covered with an exterior skin of aluminum and an interior lining of plywood. The corners have fittings for lifting and locking one to another for assembling the station. Fittings are also provided to serve as tie-down points to prevent shifting out of alignment.

At the site, each container is mounted on two or more special container support assemblies. Each leg of the assembly is equipped with two casters, a swiveled sand shoe, and an independent two-speed jack. The casters are mounted on leaf-springs that support the weight of the assembly and allow one man to easily move the assembly into position under a container. The independent jack in each leg can be adjusted to a height ranging from 34 to 50 inches, making it possible to easily and accurately level the containers on site.

13.3.2 Equipment Mounting and Installation

Equipment rack bases and bases for special cabinets such as those containing transmitters are included in the shelter design and are part of the basic structure. Most teletype equipment, furniture, safes, filing cabinets, storage and parts cabinets, and desks are attached directly to the floor.

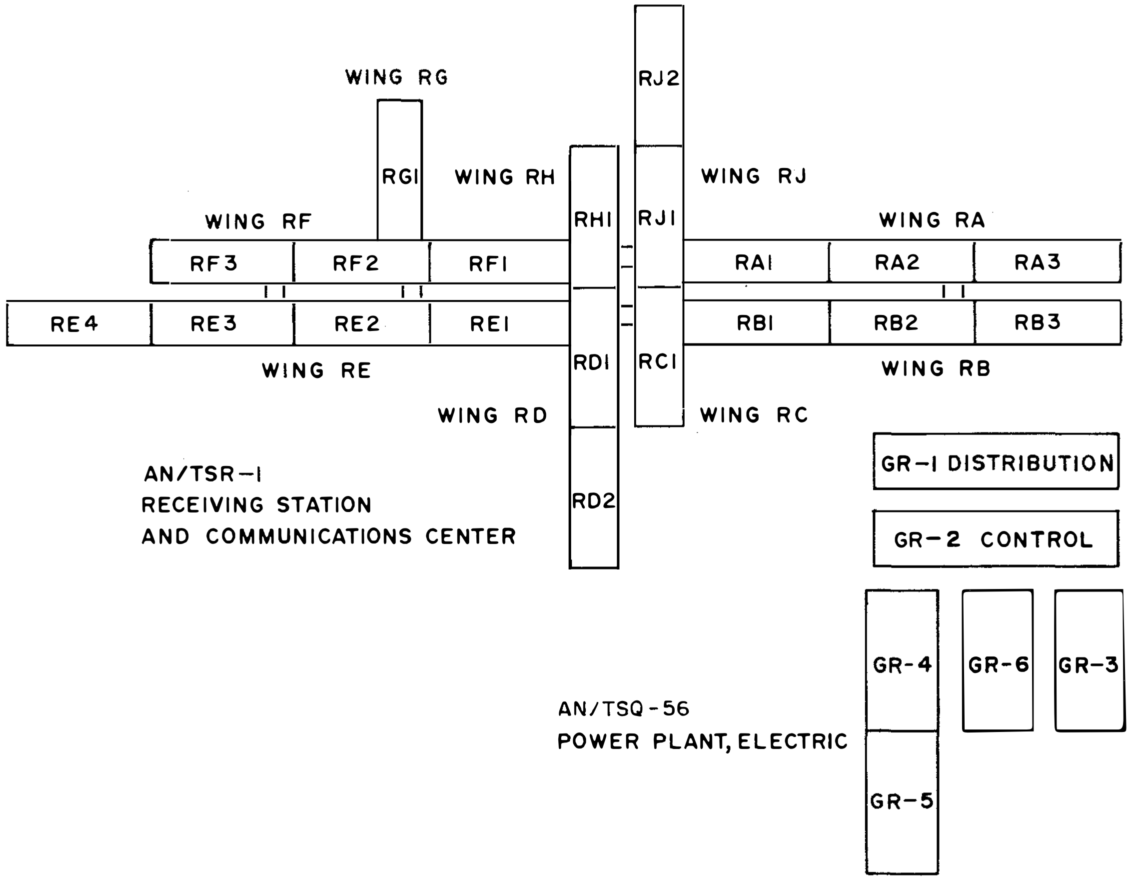


Figure 13-2. Site Plan, Transportable Communications Center and Receiver Station

13.3.3 Signal Distribution

Unless otherwise instructed, transportable stations must meet the requirements for Red and Black signal distribution as prescribed in NAVELEX Instructions 011120.1. Due to the nature of transportable structures, deviation from this instruction may be authorized on a case basis. The AN/TSC-35 shelter does provide ferrous shielding for all signal circuits. The ducting system was designed for approximately 50-percent cable loading at installation, thus allowing space for additional cable runs to accommodate future communications expansion.

13.3.4 Site Selection and Preparation

The general criteria for terrain and environmental conditions in NAVELEX 0101, 103 — "HF Radio Propagation and Facility Site Selection " is applicable to transportable equipment. After the general geographic location has been selected, careful consideration must be given to the soil bearing characteristics and wind loading to be encountered.

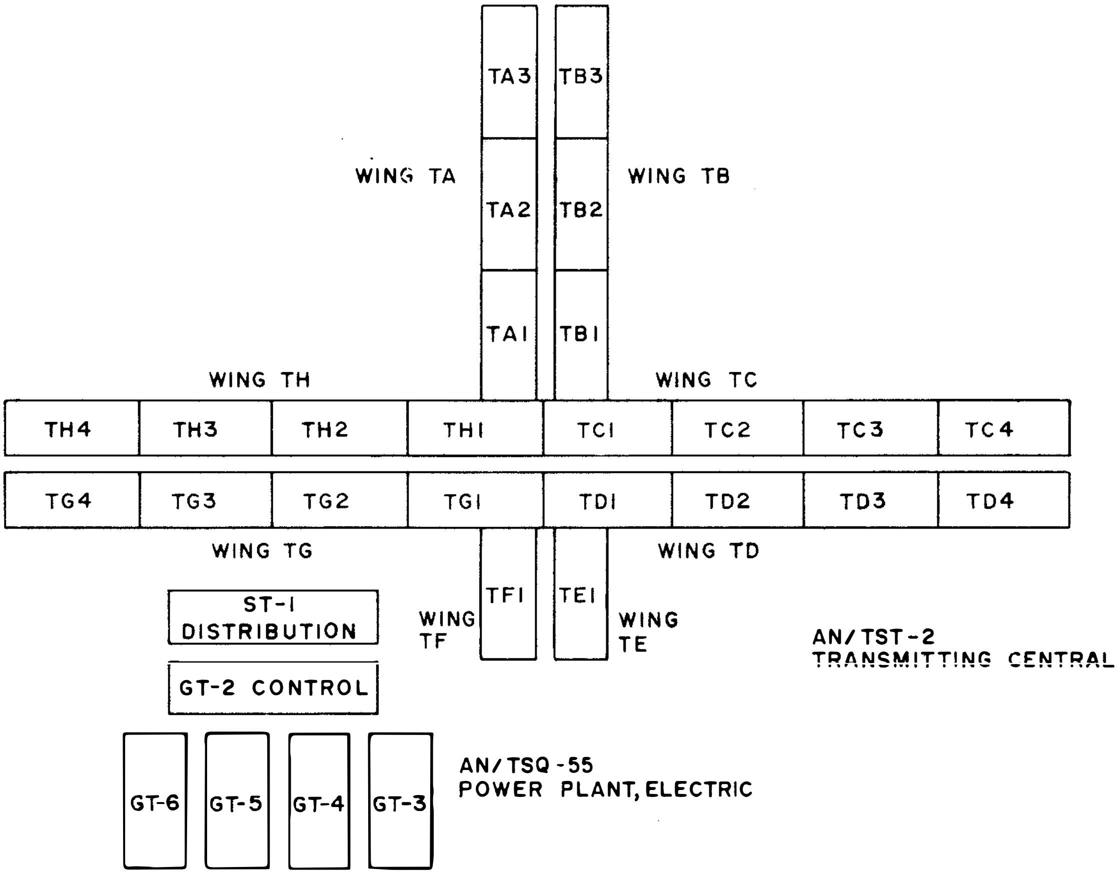


Figure 13-3. Site Plan, Transportable Transmitter Station

Table 13-3 can be used for preliminary estimates to determine the nominal bearing pressure of the soil. These soil load capacities provide a reasonable safety factor against detrimental settling and ultimate failure of individual footings. When possible, these nominal bearing pressures should be verified by inspection of nearby structures. If it appears that the soil bearing capacity is insufficient for the size of footing and the weight of the transportable activity, the installation activity must compact the soil or install concrete foundations. All transportable equipment shelters are supplied with tie-down pads which are to be secured to anchorages having sufficient uplift capacity to prevent lateral movement by the wind. A 1.5 safety factor against transient or live load forces should be designed into the anchorage (shown in figure 13-9), and pull-out tests should be performed to determine the ultimate resistance of the anchorage.

13.3.5 Earth Ground Point

The criteria of chapter 12 are applicable to the installation of the earth ground point for the transportable station. When a shelter, or a group of shelters, is to be used for signal transmission and reception only, personnel and equipment protection are the sole considerations for the design of a grounding system. For personnel protection, the earth ground connection must not present more than 25 ohms resistance to ground.

Table 13-2. Communication System AN/TSC-35 Major Components

NAME	MILITARY NOMENCLATURE
Receiver Site	RECEIVING CENTRAL AN/TSR-1
Container RA1 - HICOM/ASC	RECEIVING CENTRAL GROUP OA-3887/TSR-1
Container RA2 - Off-Line and Crypto Repair	RECEIVING CENTRAL GROUP OA-4936/TSR-1
Container RA3 - Special Receiver Container	RECEIVING CENTRAL GROUP OA-7041/TSR-1
Container RB1 - Classified Control	TELETYPE CENTRAL AN/TGC-16
Container RB2 - Crypto	RECEIVING CENTRAL GROUP OA-4937/TSR-1
Container RB3 - Crypto	RECEIVING CENTRAL GROUP OA-4938/TSR-1
Container RC1 - Multi-Channel Crypto	RECEIVING CENTRAL GROUP OA-4939/TSR-1
Container RD1 - Electronic Repair	MAINTENANCE EQUIPMENT GROUP OA-4941/TSR-1
Container RD2 - Supply	SUPPLY CENTER OA-4942/TSR-1
Container RE1 - Unclassified Control	TELETYPE CENTRAL AN/TGC-17
Container RE2 - HICOM Voice and Microwave	RECEIVING CENTRAL GROUP OA-4943/TSR-1
Container RE3 - Receivers	RECEIVING CENTRAL GROUP OA-4944/TSR-1
Container RE4 - Receivers and RF Patching	RECEIVING CENTRAL AN/TSR-2
Container RF1 - Message Center	RECEIVING CENTRAL GROUP OA-4945/TSR-1
Container RF2 - C/W Ship/Shore	CONTROL-MONITOR GROUP OA-4950/TSR-1
Container RF3 - Air/Ground	CONTROL-MONITOR GROUP OA-4951/TSR-1
Container RG1 - Communication Office	RECEIVING CENTRAL GROUP OA-4966/TSR-1
Container RH1 - TTY Repair	MAINTENANCE EQUIPMENT GROUP OA-4967/TSR-1
Container RJ1 - NTX Receive	TELETYPE CENTRAL AN/TGC-18
Container RJ2 - NTX Send	TELETYPE CENTRAL AN/TGC-19
Electric Power System	POWER PLANT, ELECTRIC AN/TSQ-56
Container GR1 - Power Distribution	POWER DISTRIBUTION GROUP OA-4968/TSQ-56

Table 13-2. Communication System AN/TSC-35 Major Components (Continued)

NAME	MILITARY NOMENCLATURE
Container GR2 - Power Control	POWER CONTROL GROUP OA-4969/TSQ-56
Containers GR3 and GR6 - Generators	GENERATOR SET, DIESEL ENGINE PU-600/TSQ
Containers GR4 and GR5 - No-Break Power	GENERATOR SET, DIESEL ENGINE PU-612/TSQ
Transmitter Site	TRANSMITTING CENTRAL AN/TST-2
Containers TA1, TA2, TB2, TB3, TC4, TD4, and TG2 - Transmitter Set 10 kW	TRANSMITTING SET, RADIO AN/TRT-17
Container TA3 - Transmitter Set 1 kW and 10 kW	TRANSMITTING SET, RADIO AN/TRT-23
Containers TB1, TC2, TC3, TD2, TD3, TG3 and TH1 - Transmitter Set 40 kW	TRANSMITTING SET, RADIO AN/TRT-18
Container TC1 - Transmitter Control	CONTROL-MONITOR GROUP OA-4915/TST-2
Container TD1 - RF Distribution	INTERCONNECT GROUP OA-4916/TST-2
Container TE1 - Transmitter Set - Low Frequency	TRANSMITTING SET, RADIO AN/TRT-19
Container TF1 - Workshop	MAINTENANCE EQUIPMENT GROUP OA-4917/TST-2
Container TG1 - RF Distribution	INTERCONNECT GROUP OA-4918/TST-2
Container TH2 - Transmitter Set 40 kW	TRANSMITTING SET, RADIO AN/TRT-20
Container TH3 - Transmitter Set 200 kW	TRANSMITTING SET, RADIO AN/TRT-24
Container TH4 - Transmitter Set 50 kW and TG4 - Low Pass Filter	TRANSMITTING SET, RADIO AN/TRT-25
Helix Container	ANTENNA COUPLER GROUP OA-4940/TST-2
Electric Power System	POWER PLANT, ELECTRIC AN/TSQ-55
Container GT1 - Power Distribution	POWER DISTRIBUTION GROUP OA-4921/TSQ-55
Container GT2 - Power Control	POWER CONTROL GROUP OA-4922/TSQ-55
Containers GT3, GT4, GT5 and GT6 - Generators	GENERATOR SET, DIESEL ENGINE PU-600/TSQ
Mobile Workshop Trailer	

1. AIR EXHAUST DUCT TYPICAL IN TA1, TA2, TC4 AND TG2 DUCT WITH RIGHT HAND ARM AT XMTR POSITION NO. 1 IN TC4 AND TA2 ONLY.
2. AIR INTAKE DUCT, TYPICAL AS SHOWN IN TA1, TA2 AND TG2. SHELF TYPE, NOT SHOWN, TYPICAL IN TC4
3. SIGNAL CABLE DUCT, 4 X 6 WITH 4 X 4 VERTICAL DROP DOWN DUCT TYPICAL IN TA1, TA2 AND TG2. 4 X 12 WITH 4 X 6 VERTICAL DROP DOWN DUCT IN TC4
4. EXTERIOR EXHAUST HOOD
5. AIR CONDITIONER CONTROL
6. AC POWER BREAKER PANEL
7. AC POWER ENTRY KICKPLATE
8. SIGNAL AND AC POWER CABLE DUCT, 4 X 4, MOUNTED AT REAR OF XMTR BASE WITH UTILITY OUTLET PER XMTR
9. CROSS CONTAINER CABLE DUCT
10. MODIFIED TMA-10K RF AMMETER
11. RF BALANCED TRANSMISSION LINE INSULATOR MOUNTING PANEL, AX-119 FEED THROUGH ASSEMBLY
12. RF UNBALANCED COAX LINE AND GAS BARRIER FEED THROUGH MOUNTING
13. FIRE EXTINGUISHER, CO_2

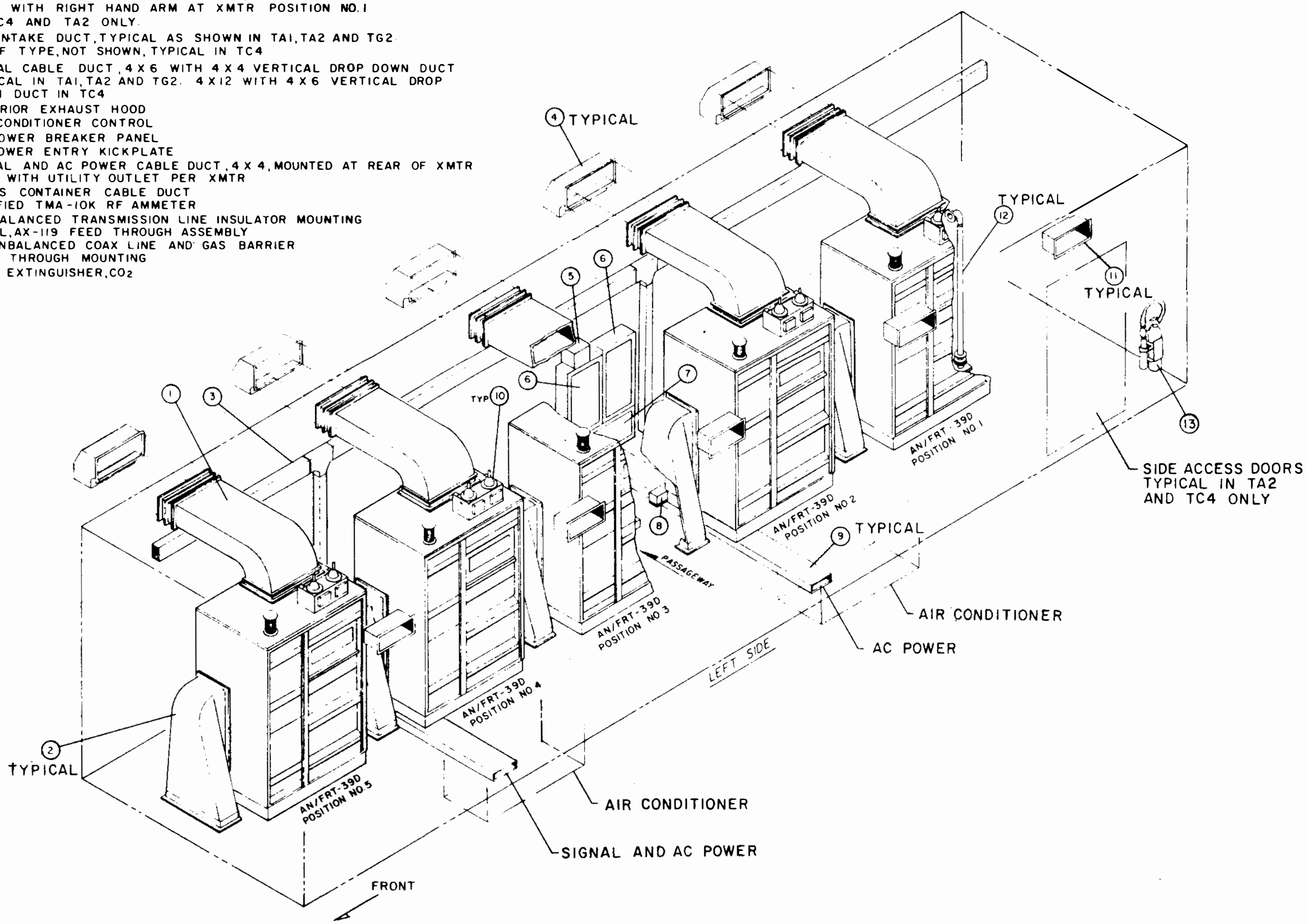


Figure 13-4. Typical Radio Transmitting Equipment Shelter

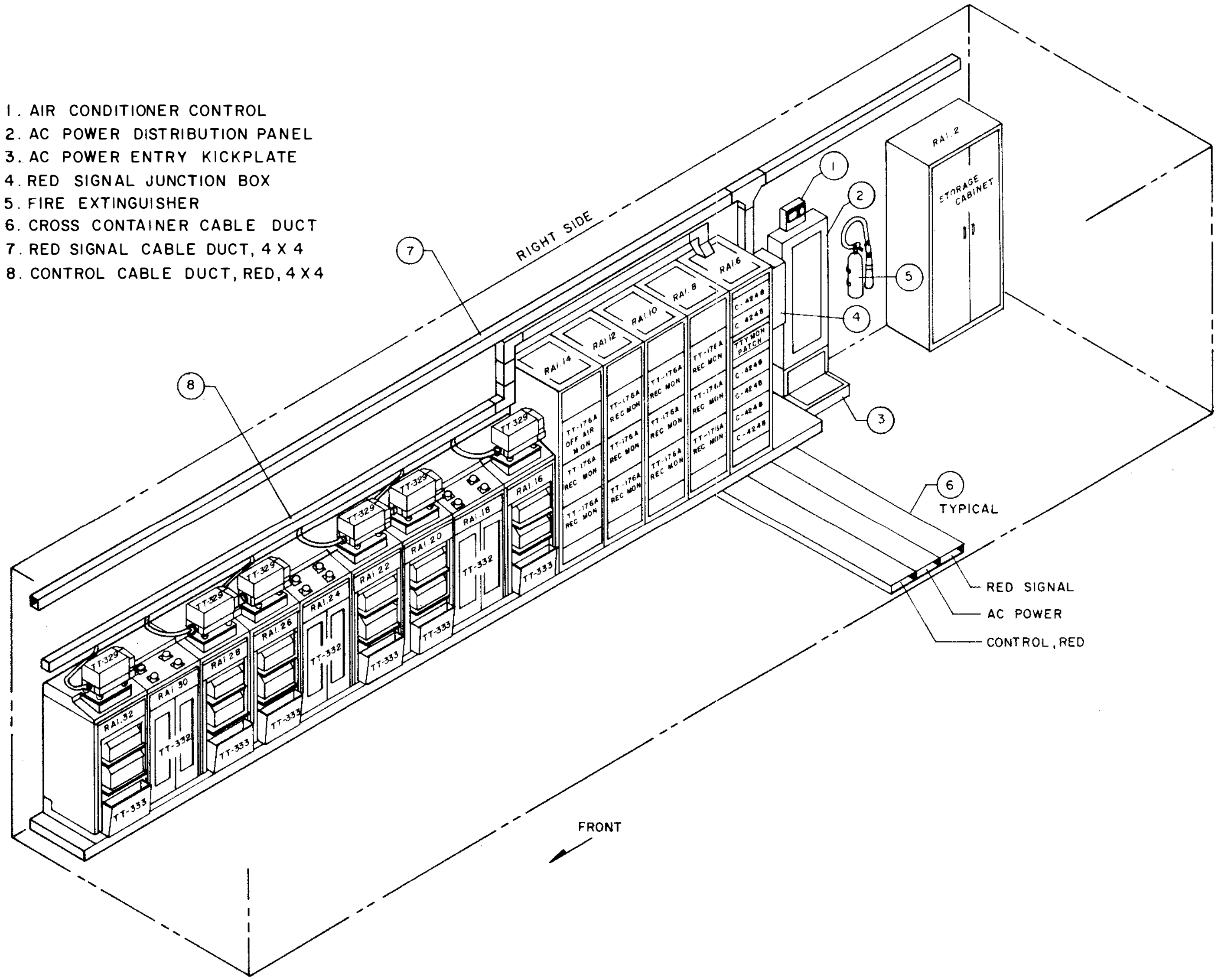
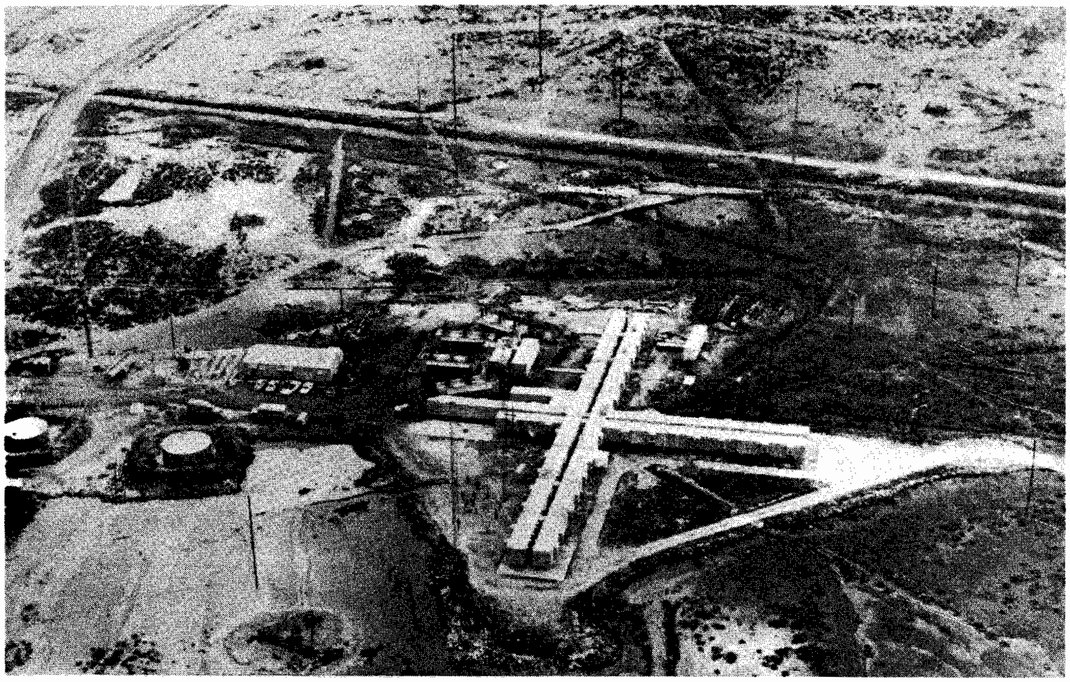
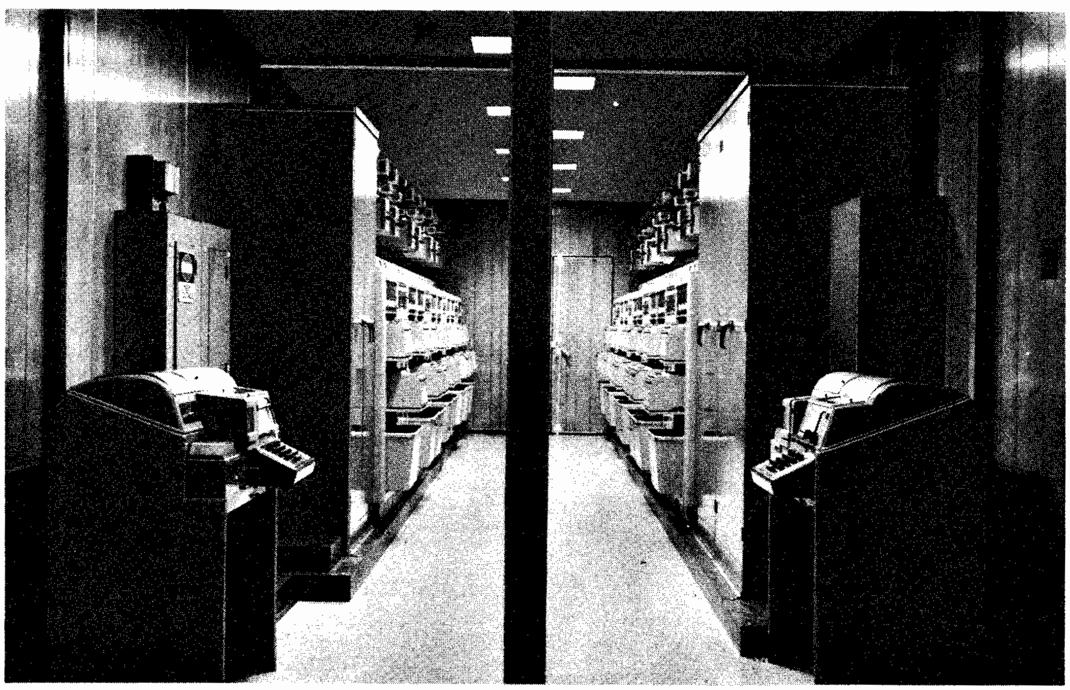


Figure 13-5. Typical Radio Receiving Equipment Shelter

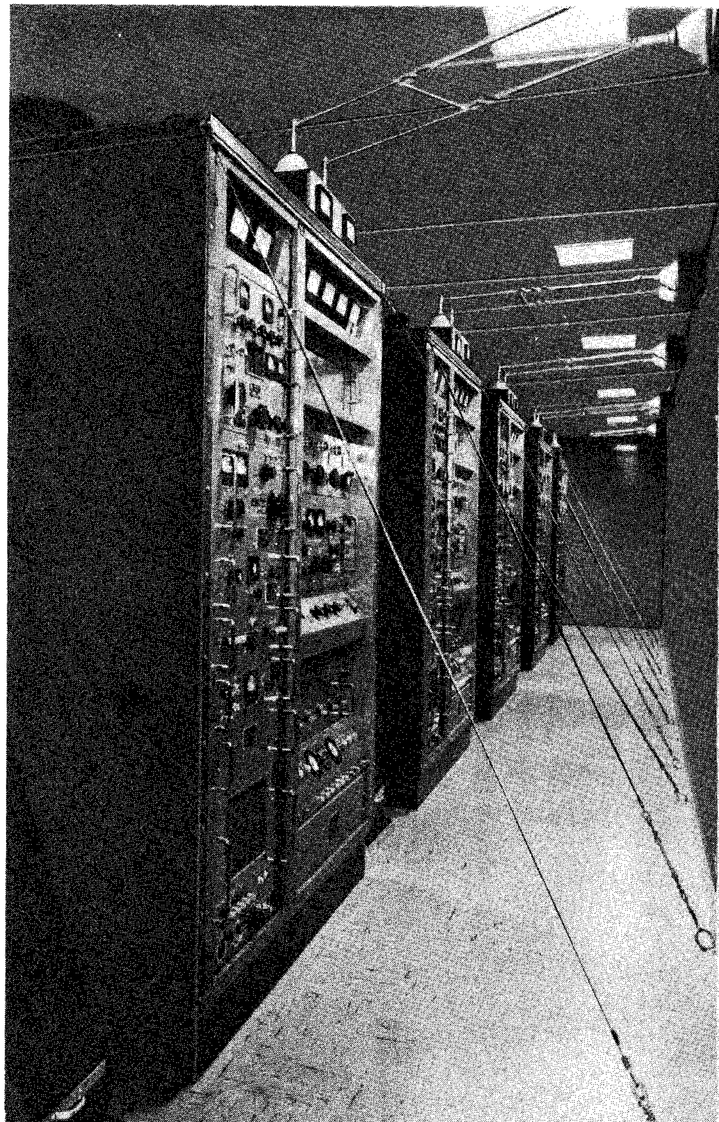


STATION COMPLEX

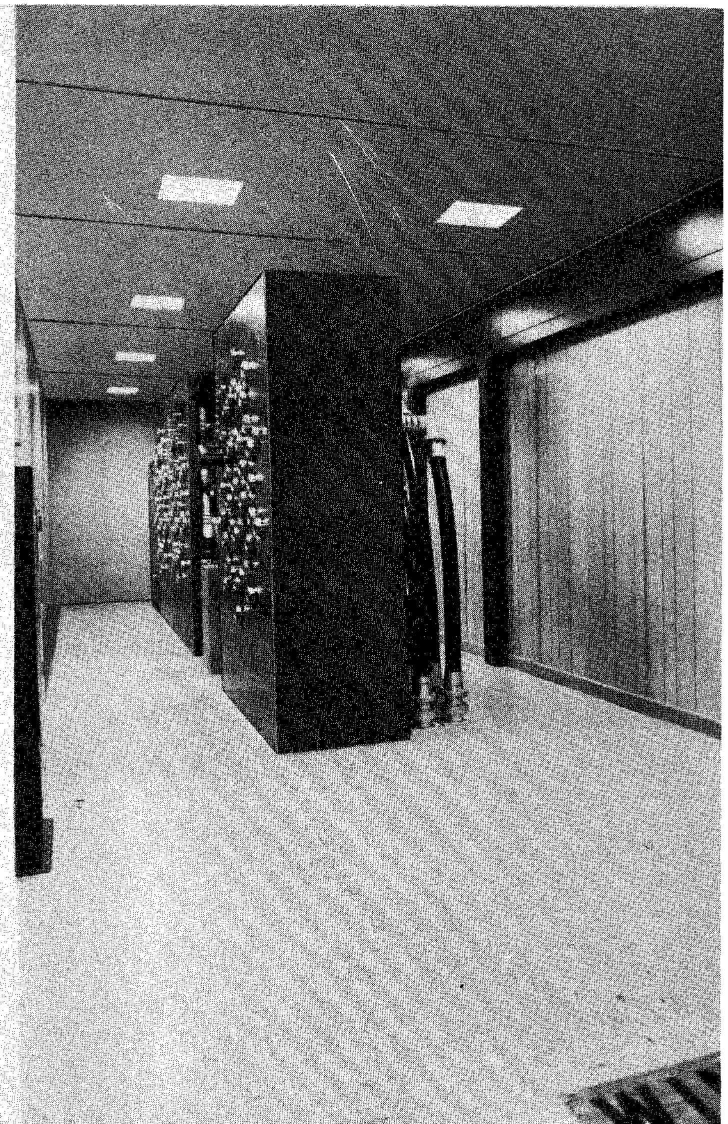


TELETYPE ROOM

Figure 13-6. Transportable Communications Center

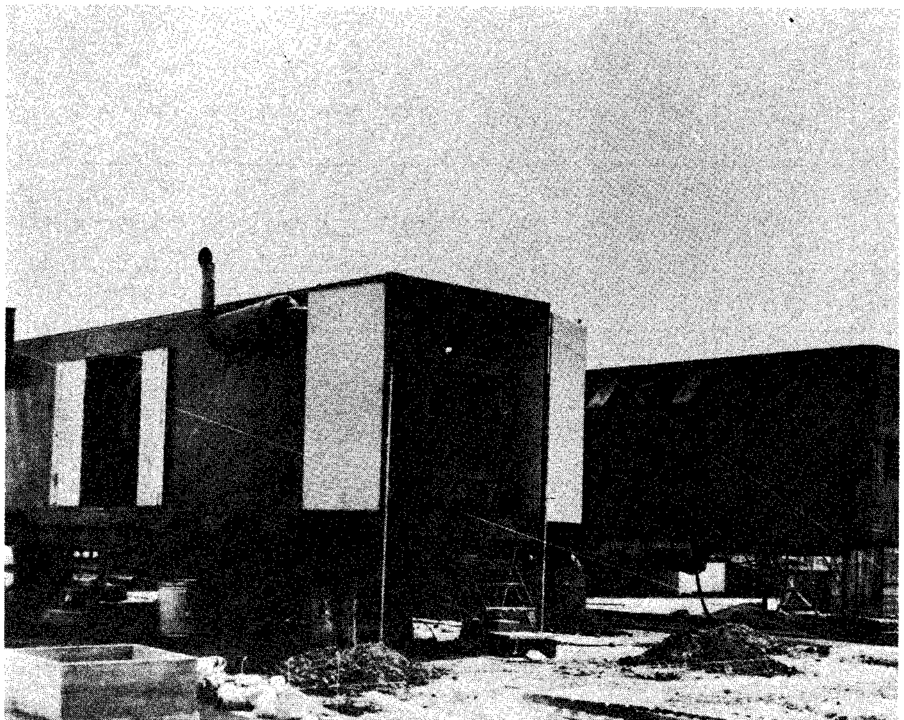


TRANSMITTERS

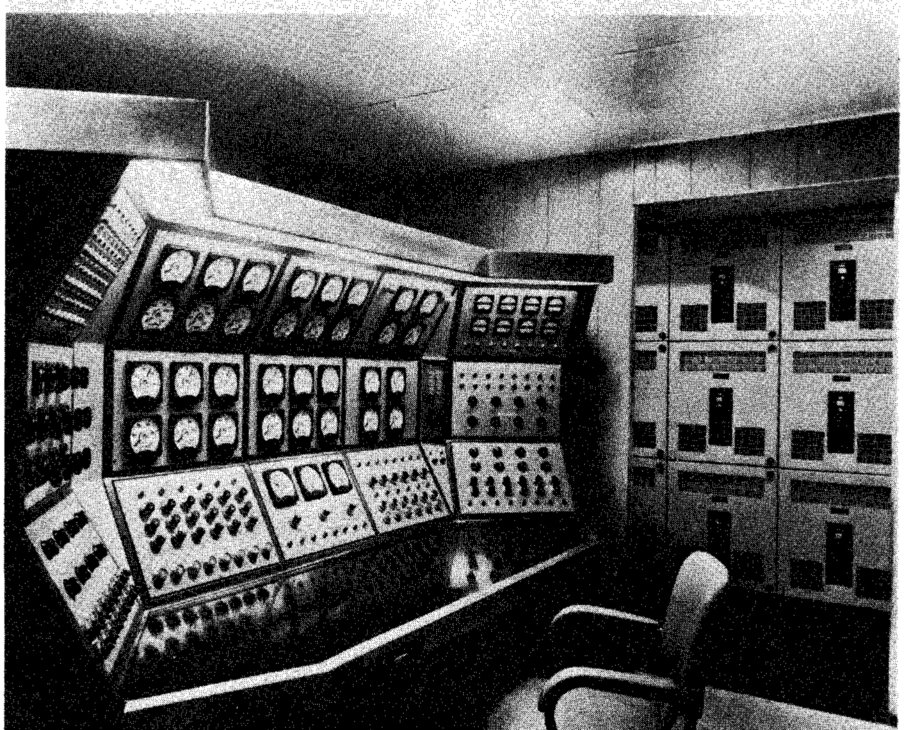


COAXIAL ANTENNA SWITCHES

Figure 13-7. Transportable Transmitter Equipment



DIESEL GENERATORS



POWER CONTROL CONSOLE

Figure 13-8. Transportable Power Equipment

Table 13-3. Allowable Soil Bearing Pressures

TYPE OF BEARING MATERIAL	CONSISTENCY IN PLACE	ALLOWABLE BEARING PRESSURE TONS PER SQ FT	
		ORDINARY RANGE	RECOM-MENDED VALUE FOR USE
Massive crystalline igneous and metamorphic rock: granite, diorite, basalt, gneiss, thoroughly cemented conglomerate (sound condition allows minor cracks).	Hard, sound rock	60 to 100	80
Foliated metamorphic rock: slate, schist (sound condition allows minor cracks).	Medium hard, sound rock	30 to 40	35
Sedimentary rock: hard cemented shales, siltstone, sandstone, limestone without cavities.	Medium hard, sound rock	15 to 25	20
Weathered or broken bedrock of any kind except highly argillaceous rock (shale).	Soft rock	8 to 12	10
Compaction shale or other highly argillaceous rock in sound condition	Soft rock	8 to 12	10
Well graded mixture of fine and coarse grained soil: glacial till, hardpan, boulder clay (GW-GC, GC, SC).	Very compact	8 to 12	10
Gravel, gravel-sand mixtures, boulder-gravel mixtures (GW, GP, SW, SP)	Very compact	7 to 10	8
	Medium to compact	5 to 7	6
	Loose	3 to 6	4
Coarse to medium sand, sand with little gravel (SW, SP)	Very compact	4 to 6	4
	Medium to compact	3 to 4	3
	Loose	2 to 3	2
Fine to medium sand, silty of clayey medium to coarse sand (SW, SM,SC)	Very compact	3 to 5	3
	Medium to compact	2 to 4	2.5
	Loose	1 to 2	1.5
Fine sand, silty or clayey medium to fine sand (SP, SM, SC)	Very compact	3 to 4	3
	Medium to compact	2 to 3	2
	Loose	1 to 2	1.5
Homogeneous inorganic clay, sandy or silty clay (CL, CH)	Very stiff to hard	3 to 6	4
	Medium to stiff	1 to 3	2
	Soft	.5 to 1	.5
Inorganic silt, sandy or clayey silt, varved silt-clay-fine sand (ML, MH)	Very stiff to hard	2 to 4	3
	Medium to stiff	1 to 3	1.5
	Soft	.5 to 1	.5

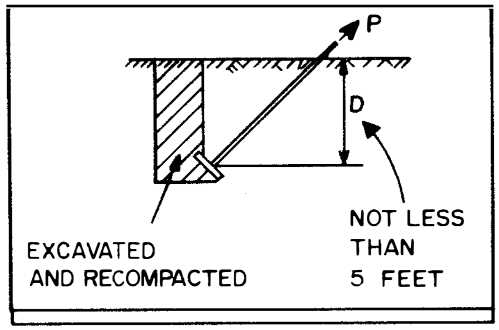


Figure 13-9. Guy Anchorage to Resist Axial Load

APPENDIX A

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